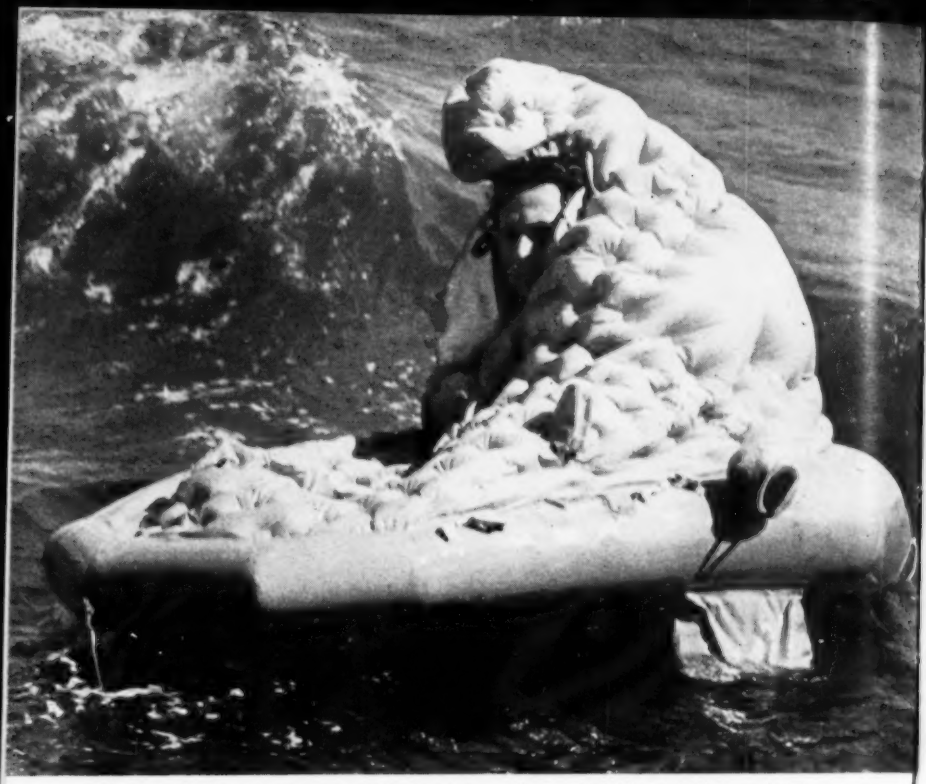
Sea Frontiers

Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION

September, 1957

Volume 3, No. 3



THIS ISN'T JONAH IN THE WHALE'S MOUTH, *but a British jet fighter pilot in a new type of inflatable dinghy. Its canopy, enclosing the "survivor" and preserving body heat, and its air-cushioned floor, are blown up by specially designed gas cylinders. (British Information Services)*

FRONT COVER: A QUIET MOMENT *along the battlefront where sea and shore meet. The solitude of the Wingaersheek Beach dunes in Gloucester, historic Massachusetts fishing port, is broken only by the soaring flight of a sea gull. The lighthouse in the distance is Annisquam. (Massachusetts Dept. of Commerce)*

BACK COVER: SPINNAKER SET, HILARIA, *a 55-foot centerboard yawl owned by Hugh Schaddelee, runs through light chop to the Sunny Isles in the annual Lipton Cup races, off Miami, in 1957. (Charles E. Lane)*

SEA FRONTIERS

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Application for second class mail privilege is pending at Miami, Florida.

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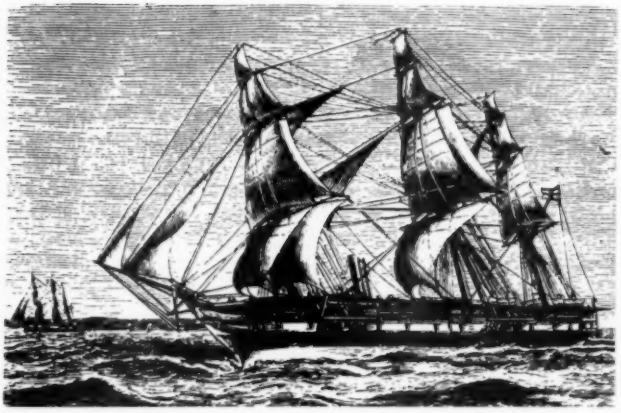


VOLUME 3, NO. 3. SEPTEMBER, 1957

THE HAWAIIAN SLING, *a rubber-band powered weapon, in action on the Florida reefs. The spearman seeking a Nassau grouper shows how specimens may be secured in places that cannot be reached by ordinary hook and line, or by net fishermen. He is using a free spear of small diameter, a type specially suited for scientific collecting. (Walter R. Courtenay, Jr.)*

Anglers Versus Spearmen

By E. JOHN LONG

THERE is an old saying "Oil and water do not mix." This axiom seems to apply also to two groups of fishermen—anglers, who seek their quarry with the traditional hook and line, and spearmen, who use spears, gigs, and special slings and underwater guns.

Tidal areas along the shore and around outlying reefs, where some of the best saltwater fishing is to be found, do not now seem to be large enough for both, if we may judge from the volleys of charges and counter-charges, claims and counter-claims, and assorted complaints and criticisms that anglers and spearmen have tossed back and forth at each other recently during conservation meetings, in the public press, and at hearings held in various State legislative halls.

Meanwhile, marine biologists and fishery management experts have undertaken scientific investigations in order to ascertain just what is happening to the innocent victims—the fishes themselves.

Neither Hook nor Spear New

The squabbling is of comparatively recent origin, although the taking of fish with barbed hooks of bone or

metal, as well as with spears and gigs, goes back to the very beginnings of man as a predatory creature.

As a sport and pastime, hook and line fishing has a most venerable and highly respected ancestry. In Izaac Walton, anglers possess a legendary figure that has become their own patron saint. Skindiving, which makes underwater spearfishing possible, has only recently been classified as a sport. Between 1930 and 1935, with what would now be considered very primitive gear, a few hardy souls tried it in the clear waters off Florida, California, Hawaii, and the Mediterranean coast of France.

"Frogmen" Advanced Techniques

World War II temporarily halted the development of skindiving as a sport, although Navy "frogmen" of several nations, probing enemy mine fields and harbor defenses, advanced underwater techniques and built a nucleus of men interested in the exploration of a fascinating new domain just beneath the surface of the sea. In marine biological research, improved skindiving techniques replaced the diving helmet or hood for underwater work and proved to be a valuable scientific tool, especially for direct observation of living creatures and conditions of the sea floor.

The first skindivers carried spears and crude underwater guns, they explained, to protect themselves from attack by large fish. In their own element, however, fish were found to be most friendly; so friendly that they could be shot with ease from short range.

National Contest in 1950

Later, the spearing of fish was proclaimed to be a definite sport, with awards offered to those who, in competition, brought up the largest fish, or greatest poundage of fish. The number of spearfishing clubs grew so rapidly that, by 1950, a national underwater fishing contest was held at Laguna Beach, California. Scores of skindivers, using the latest in SCUBA (self-contained underwater breathing apparatus) participated, and the resultant publicity vastly increased the sale of fins, masks, compressed air tanks, aqualungs, underwater slings and guns, and other equipment.

While the ranks of spearfishermen increased rapidly in many parts of the world, perhaps the most spectacular growth was in South Florida. Clear seas and abundant fish life along all of its coastline attracted not only local spearmen, but those from many other parts of the United States and from Canada. Numerous spearfishing clubs were formed, especially along the lower East Coast and down along the Keys, as well as in the Tampa-Sarasota-Bradenton area. Hundreds of other spearmen tried their lances without joining any club or organization.

Anglers of the Old School

The region that took the real brunt of this rising tide of amateur or novice spearmen was the Upper Keys of Monroe County, just below Miami, where formerly scientists and students from the Miami Marine Laboratory, with an occasional underwater camera

MARINE BIOLOGISTS AND UNDERWATER CAMERA FANS *also use underwater diving equipment for the study of life along the Florida coral reefs. In fact, before spear-fishing became popular, they were almost alone in this fabulous world, except of course for striped grunts, blueheads, tangs, and other brilliant fishes. (Jerry Greenberg)*

fan, had the world beneath the sea almost to themselves.

These delectable isles, surrounded by crystal clear waters, concentrations of fishes, and with an equitable year-round climate, have been a favored vacation and fishing Mecca for anglers of the old school for many decades. The facilities of the Keys—fishing camps, taverns, motels, stores, charter boats, bait sellers, etc.—are geared to the leisurely quest of reef and bottom fishes, plus some more exciting deep-sea game fishing, all of it with hook and line, rod and reel. Some days the hauls are good; on other days "the fish are just not biting." That's the sport of it, the conchs, as they call the residents of the Keys, tell you.

A Thorn In Paradise

Then came the skindivers, and the spearmen. Youngsters mainly and, as is the way of youth, full of zest and eager to put their new equipment to the test. But a minority among them swam down among the anglers' lines, particularly on the days when fish were not biting, and speared a few choice specimens. These they brought to the surface and displayed derisively to frustrated anglers and annoyed charter boat captains.

When the charter boat skippers cussed out the spearmen, and blamed them for scaring fish away, the more unruly goggle boys snipped fishing lines, made off with expensive plugs, and otherwise made a general nuisance of themselves. It was great fun for some of the aqualung jokers, but it was something more than a thorn in paradise to the charter boat men and others who derived their living from pleasing rod and reelers. It could write *finis,* if unchecked, to the chief industry of the Upper Keys.

"Code of Ethics" Drawn Up

At least that was the feeling among residents of the Keys in 1950, even among those who recognised that only a minority of the spearmen caused trouble. Letters from all over the country, most of them from old-time anglers who annually spend their vacations fishing in the Keys, urged that something be done about the situation.

In 1951, a series of meetings was held between business and conservation groups of the Keys, and representatives of several organized clubs of spearmen. A satisfactory "Code of Ethics" was drawn up and approved. Unfortunately, this effort failed, chiefly because the majority of skindivers and spearmen did not belong to any organized groups. Some spearmen derided controls of any kind, terming the Keys residents "old conch," who resent any "change or progress."

"Weekend Warriors"

In a report to the Izaak Walton League of America, G. A. Ellis, of the Upper Keys Conservation Council, describes the next interlude: "So spearmen came in every increasing numbers... the 'weekend warriors' took over. They dove among the lines of anchored fishing boats. When the boats moved, the spearmen followed. Spearmen brought in strings of colorful but inedible reef fishes, and left them on the docks to rot. They left blood and filth in the rented skiffs. Tarpon was abandoned

SOUTH AND WEST OF MIAMI *a series of keys are strung together along the Overseas Highway like gems on a necklace. In the emerald and turquoise waters on each side of the Keys are some of the world's best fishing grounds. A new law, banning spearfishing in the upper Keys, has become a bone of contention between spearmen and anglers. This view shows Bahia Honda, in the lower Keys, where spearfishing is permitted. (Florida State News Bureau)*

for residents to dispose of. Wounded fish swam with their intestines trailing. Many speared and decaying fish were washed up on our shores."

Finally feeling reached such a level that the Florida Legislature passed an Act to prohibit spearfishing within a mile of the Overseas Highway (US 1). For a time this relieved the tension around the bridges and channels, although the statute was never too rigorously enforced, nor could it be without a large staff of agents, for which the law did not provide.

Mystery of the Gray Snapper

Meanwhile, spearfishing on the reefs or in any area a mile from the highway went on unrestricted. There were reports of certain "holes" being depleted, and species, such as gray snapper, suddenly becoming quite scarce. While no one could prove that spearmen alone were to blame, old-time sports anglers began to leave the Keys. Some of them blamed the antics of spearmen more than any toll of fish they may have taken.

Now came another cloud to darken the horizon. Amateur spearmen were replaced, in certain areas, with what might be called highly efficient professionals. In illicit night operations these expert divers were reported to be running up catches as high as 500 pounds per man. Rushed to Miami markets (without benefit of icing or other refrigeration) such fish netted higher than any in regular commercial operations.

An Edict and a Study

Obviously some further step would have to be taken, if only to check the

bitterness that was growing between Key residents and spearmen from outside areas (principally Miami). The whole situation was fraught with danger, and needed only a spark to set off a powder keg of trouble, and possible violence.

Residents and others interested in rod and reel fishing, with the help of the Monroe County Board of Commissioners and the legislative delegation of Monroe County, persuaded Ernest Mitts, director of the State Board of Conservation, to issue an edict against all spearfishing in the Upper Keys. At the same time, Mitts asked the Marine Laboratory of the University of Miami to make a scientific study and report on spearfishing practices for the Conservation Board.

A Storm of Protest

"Resolution No. 21," the anti-spearfishing rule of the Conservation Commission, aroused a storm of protest from skindivers all over the nation. They claimed the resolution was much too drastic, punishing orderly spearmen as well as infractors. Anglers themselves, they pointed out, were not above "over-fishing practices" when the fish were "biting good." Spearmen cited instances of anglers bringing back far more than a fair share of fish, in order to make a boastful dockside appearance and photograph, after which most of the fish were tossed in the trash can. Outraged spearmen growled about people who live in glass houses.

Florida's Governor LeRoy Collins finally entered the picture by confirming the right of the Conservation Commission to impose Resolution No. 21, but he added that such a ruling could not be permanent. It would have to be backed up by regular statute at the next session of the Legislature, or automatically expire. The 1957 Legislature did just

BRIDGE FISHERMEN *sometimes find the competition and interference of spearmen more than irksome. Lacking mobility, bridge and pier fishermen resent even the presence of hook-and-liners in boats when they anchor or drift in their vicinity. These men are finding good sport off Rickenbacker Causeway, Miami. (City of Miami News Bureau).*

PARTY BOAT ANGLERS ANNOY SPEARMEN *by boastfully displaying large catches. On the other hand, many rod and reel anglers blame spearmen for "mass destruction" of certain varieties of fish. Obviously, there are two sides to this question. (Florida State News Bureau)*

that, officially extending the ban as far south as Long Key. Even the possession of spearfishing equipment on or under the waters of upper Monroe County would result in fines or a jail sentence. However, the law did not ban skindiving as such, and the Keys welcome those who would explore or photograph under water, without weapons.

What Study Revealed

What of the scientific study of the effects of spearfishing, ordered by the Conservation Board? In 1951, the Florida State Board of Conservation had asked the Marine Laboratory to make a preliminary investigation in Palm Beach County, to determine whether the methods of spearfishing were contrary to conservation aims and practices—such as control of exploitation of fish stocks, so as to give the maximum sustained yields to all legitimate activities, whether sports or commercial fishing, and whether by seining, hook and line, or spearing.

The resulting report (Brady, 1951) found that in the area investigated there appeared to be no fundamental conflict between ordinary spearfishing and the above aims and concepts which could not be reasonably resolved. The report cannot be considered definitive, because snook was the chief species involved in the study, and the wily snook is not a special favorite of spearmen. However, the report also looked into night-time spearfishing, on a commercial basis, and strongly recommended that this be halted as injurious to the purely local fishery, both commercial and sport. It also suggested banning cer-

tain favored angling spots to spearmen.

In the 1956-57 survey, made by James Murdock, formerly of the Marine Laboratory and now of the U.S. Fish & Wildlife Service, catches by Monroe County spearmen, hook-and-line anglers, and commercial fin fishermen were estimated for a year—from August 1, 1955 to July 31, 1956. Estimates were based on a canvass of twenty places where fishermen were known to rent, launch or charter boats for offshore fishing.

Spearmen a Poor Third

Final tabulations showed that spearmen, within this period, caught some 207,000 pounds of fish, all other sport fishermen an estimated 1¼ million pounds of fish, and commercial fisheries about 2,473,000 pounds. According to this survey, users of spears ran a poor third in the amount of fish taken. Except for night operations, for which no accurate estimate can be made, spearmen therefore represent no real conservation or other threat where they are not making a nuisance of themselves—a sociological aspect of the problem that must be considered.

Murdock found definite evidence of interference between anglers and spearmen, particularly on the reefs and near bridges, and this became more acute as the number of fishermen increased. The potential danger of the spear gun as a weapon, both in and out of the water, is another social problem.

How Others Regulate Spearmen

The Murdock report also makes note of methods used to regulate spearfishing in other parts of the world, and which have been suggested for Florida: (1) bag limits; (2) species restrictions; (3) closed seasons; (4) gear restrictions, and (5) area restrictions.

Based on his year's research, Murdock made the following recommendations:

(1) Spearfishing should be recognized as a legitimate sport activity.

(2) Species restrictions, closed seasons and gear restrictions are not believed to be useful in solving the problems of spearfishing in Monroe County.

(3) Bag limits are not recommended at present.

(4) Area restrictions, prohibiting spearfishing in certain areas, but allowing this type of fishing to have the exclusive use of other areas, is suggested as a possible control.

(5) Night spearfishing with an artificial light should be banned.

(6) Sale of speared fish should be banned. So should sale of *all* fish caught by sport anglers.

(7) Spearfishermen should be obliged to secure a license from the State Board of Conservation, provided other types of sport fishermen are also licensed.

(8) The information needed to decide whether conservation is being served is lacking. Catch data and biological information concerning the local habitats and the biology of the fishes found is essential. To gather and analyze basic data would require lengthy research, but it should be started.

RECOVERING A NASSAU GROUPER shot *with a Hawaiian sling off Key Largo, Florida. This picture gives a closeup also of the air tank strapped to the diver's back and the breathing aparatus. Gloves are worn to avoid scratches and bleeding which might attract sharks. (Walter R. Courtenay, Jr.)*

Other Spearfishing Bans

Another survey, made by the Upper Keys Conservation Council, shows that sixteen Florida counties, in addition to Monroe, have restrictive laws on spearfishing. In areas of the Bahamas, and in Bermuda, spearfishing with aqualungs is prohibited, thus limiting the number of fish that can be taken. A compilation of fishing laws in American States having coastal waters shows that sixteen of the twenty such States already have some kind of restrictions on spearfishing, ranging from a complete ban in Maryland and Oregon, to local regulations in other States. Everglades National Park, the largest public domain fronting salt water, allows no spearfishing.

Anglers won a round, psychologically speaking, when the Amateur Athletic Union, after admitting "Underwater Spearfishing" as a sport, changed its listing to "Competitive Skindiving." Prizes are still awarded, however, for the *greatest poundage* of fish speared by three-man teams. At the AAU Florida State championship meet, held in Marathon in 1956, the winning team boated 179 pounds of fish in four hours, a feat which rod and reelers derided as "mere *kill*, and competitive *kill* is not a sport."

But, compared to this, spearmen point to the 40,000 pounds or so of bluefin tuna landed by competitive anglers at the Bimini and Cat Cay tuna tournaments, and to the poundage premium in sailfish competition.

Conservation as a Factor

While conservation is undoubtedly an important factor in the controversy between anglers and spearmen, more scientific research and analysis must be conducted in the Florida Keys area before it can be established that one type of fishing or another is to blame for seasonal or even yearly variations in the abundance of certain species of fish. The "holes" where gray snappers have congregated can be "fished out" as well as "speared out." Some charter boat captains do not make sufficient efforts to find new fishing grounds when the ones familiar to them fail to produce, offering as an excuse "those blankety-blank frogmen."

A good part of the hassel in the Upper Keys has, of course, stemmed from a valiant attempt on the part of

the residents to preserve a pleasant and traditional way of life for themselves and their regular guests. In recent years, some 75,000 rod and reel fishermen from all over the nation have come there annually to match wits and skill with many fine varieties of bay and reef fishes, and the big marlin and sailfish offshore in the Gulf Stream. Thousands of other anglers fish in the Upper Keys area from skiffs, bulkheads and bridges. All of them like things as they are, or were, with no distractions or annoyances—other than the customary and quite ferocious Key mosquitoes.

Scaring the Fisherman!

The closer one examines the Upper Keys fishing situation, which could set a precedent for the rest of the nation and elsewhere, the more apparent it is that the cardinal sin of the spearmen is not that they have shot out or scared off the fish, but that they threaten to drive away the old-time hook and liners. As the latter represent an "industry" that brings some $5,000,000 a year to the Upper Keys, and as spearmen as yet mean no more than a fraction of that sum, residents of the area realized where their bread is buttered, and have acted accordingly. However, the

PIER FISHING IS EASY AND INEXPENSIVE. *If you can't afford a charter boat, or a party boat, or if boat fishing makes you seasick, there are scores of piers along the Atlantic and Gulf coast States that give access to good-sized saltwater fish free, or for a small fee. (Florida State News Bureau)*

SUNSET SILHOUETTES A CHARTER BOAT *rolling in the blue waters of the Gulf Stream. These rod and reelers are well beyond the reach of spearmen, who, in shallower waters, sometimes irk charter boat captains and their patrons by coming up with speared fish on days when fish "just aren't biting." (City of Miami News Bureau)*

entire Keys area is potentially the most lucrative for spearfishing in America, according to estimates made by spearfishing experts.

"Conservation of fish resources," was the rallying cry, and while unquestionably there will be more fish in an area where the number of fishermen is restricted, the sincerity of the Upper Keys residents, and of the conservationists, too, will remain under somewhat of a cloud as long as they look the other way when anglers bring in far more fish than they should. A hopeful sign is the growing number of anglers who release all inedible fishes, and also other catches that they do not expect to eat, or to give to a limited circle of friends.

Is It a "Growing Pain?"

Those on both sides who have explored this ticklish situation, and the writer talked to quite a few in an effort to arrive at an impartial view-

point, agree on one thing—the anglers versus spearman controversy is also one of the "growing pains" of an age of unprecedented sports activity and expansion. It has been estimated that today one out of every seven persons in the United States is either a fisherman, or is interested in learning how he (or she) can become one —but soon. This makes fishing by far the most important *participator* (as distinguished from *spectator*) sport, with no indication that its popularity will do anything except increase.

Will there still be enough fish and fishing places to go around? Of course, but we may have to revise our thinking somewhat about conservation and kindred matters. Old concepts of conservation, for instance, may well give way to a new format, which, for the lack of a better term, might be called "fisheries management."

Multiple or Maximum Use

One of the basic principles of wise fisheries management is multiple or maximum utilization of the sea's resources, not just for the angler alone, or for the commercial fisherman, or for the spear fisherman, but the best possible regional use for recreation, food and sport jointly.

It is obvious that such an application for the benefit of mankind must be based on continuous scientific research, and on level-headed interpretation of the findings by qualified and impartial experts. Nothing much is gained in the long run by laws or regulations that completely *prohibit* the activities of one group, and thus automatically *favor* others.

At the same time, each of us who would use and enjoy the sea's largess must assume some responsibility for our actions, and must make some concessions so that we shall not obtain more than our fair share. This means respecting the rights and prerogatives of others. Self-discipline, and above all courtesy and fair play, should be the guiding rules, with recourse to resolutions and statutes only as a last resort. When laws become necessary, biological, economic and sociological factors, rather than hasty emotions or purely local politics, should influence the choice of controls.

For Further Reading:

Dive: *The Complete Book on Skin Diving*, by Rick and Barbara Carrier. Wilfred Funk, Inc., New York 1957. Profusely illustrated with photos, charts and drawings. A volume that will interest and assist both amateurs and professionals.

Underwater Sport, by Albert Vander-Kogel with Rex Lardner. Henry Holt & Company, New York, 1955. One of first books on skin diving, and still an authority, as well as good reading.

Underwater Photography Simplified, by Jerry Greenberg. Seahawk Products, Coral Gables, 1957. Helpful pointers for those who would capture a strange world on film, in either black-and-white or color.

Man and the Underwater World, by Pierre DeLath and Jean Rivoire. G. P. Putnam's Sons, New York, 1956. A fascinating story of the experiences of divers of all ages, not neglecting those of Greece or Rome, nor the schemes of Middle Ages inventors, such as Leonardo da Vinci.

FILTERING PLANKTON *through a silk net, a marine biology student of Andhra University is assisted by an Indian boatman. The boat is a catamaran—two logs tied together but not caulked. Thus the water from the net can easily drain through the bottom of the boat. (E. C. LaFond)*

Science And The Indian Ocean

By T. S. SATYANARAYANA RAO

DR. ANTON BRUNN, the leading naturalist of the *Galathea* Expedition, remarked to us in one of his illuminating lectures on the deep sea fauna that perhaps "we know more about certain areas of the distant moon than some of the oceans of our own planet." The truth is that our knowledge of the oceans and their inhabitants is far from satisfactory and this is particularly the case with the Indian Ocean, about which very little is known.

Economic Importance

It will not be out of place here to mention the extreme importance of marine products in the general economy of the nations bordering the Indian Ocean. Most of these nations are thickly populated. Their land resources of food are inadequate and cannot meet the growing needs of their ever increasing population. In order to become self sufficient and to have a decent standard of living with regard to food, it is necessary and even imperative for them to augment their food resources by a rational exploitation of the nearby sea. Before this can be done, of course, a systemmatic exploration of the Indian seas, on a scientific basis, will be needed. If this is undertaken, it might not only reveal interesting oceanographic phenomena peculiar to the Indian Ocean, but may also lay bare hitherto unknown areas rich in fisheries.

The responsibility for this obviously rests with India, because of its central situation commanding the Indian Ocean. Perhaps it is not too late for the organizers of the International Geophysical Year and for the members of the Advisory Committee on Marine Sciences to UNESCO to take steps toward developing active interest in the participating countries for filling this oceanic gap in our studies of the great and wide seas in the coming years.

Previous Expeditions

In the past, several oceanographic expeditions have passed through the Indian Ocean on the way to other areas in the Pacific or the Antarctic. Only a few of them, namely the Percy Sladen Trust Expedition, the John Murray Expedition, the *Dana*, the *Snellius* and the Swedish Deep Sea Expedition, actually spent considerable time in the investigation of parts of the Indian Ocean, mostly in the southwestern area. The reports of these expeditions and the results of the investigation of H.M.S. *Investigator* in the Indian seas published by R. B. S. Sewell are the most important publications on the oceanography of the Indian Ocean.

Bay of Bengal and Arabian Sea

More recently, the Andhra University at Waltair, the Central Marine Fisheries Research Station, Mandapam Camp, and its branches situated

WARDROOM *of the* I. N. S. Rohilkhand, *an Indian naval vessel assigned for oceanographic work. The officers with white turbans are Sikhs, whose custom is not to shave or cut their hair. (E. C. LaFond)*

elsewhere along the coast of India, have undertaken various projects in oceanography of the Bay of Bengal and the Arabian Sea. Mention should be made here of the valuable services rendered to the cause of oceanography in Indian waters by Professor E. C. LaFond of the U. S. Navy, who, during his visit to India in 1952 and 1955 under the Fulbright scheme, initiated and trained a number of students and staff at the Andhra University. Under his leadership and with the active cooperation of the staff of the Andhra University and the Indian Navy, about fifty short and long cruises have been conducted into the various coastal areas of the Bay of Bengal. The results are now being published.

Oceanographers are aware that the Indian Ocean is peculiar in many respects. It differs from the wide Pacific and the narrow Atlantic in being completely cut off from the Arctic Ocean by the presence of the huge Asiatic land mass. Hence there is no subpolar water mass in the Indian Ocean. Further, the northern part of the Indian Ocean is subject to the alternating influence of the seasonal monsoons which are known to bring about sweeping changes in the directional flow of the surface currents and the attending oceanographic factors. Added to these, the waters of the Bay of Bengal are tremendously diluted during the rainy season when the major river systems of peninsular India and Burma discharge vast quantities

of mud laden waters into the Bay. These factors should have considerable influence in the oceanography of the Indian Ocean.

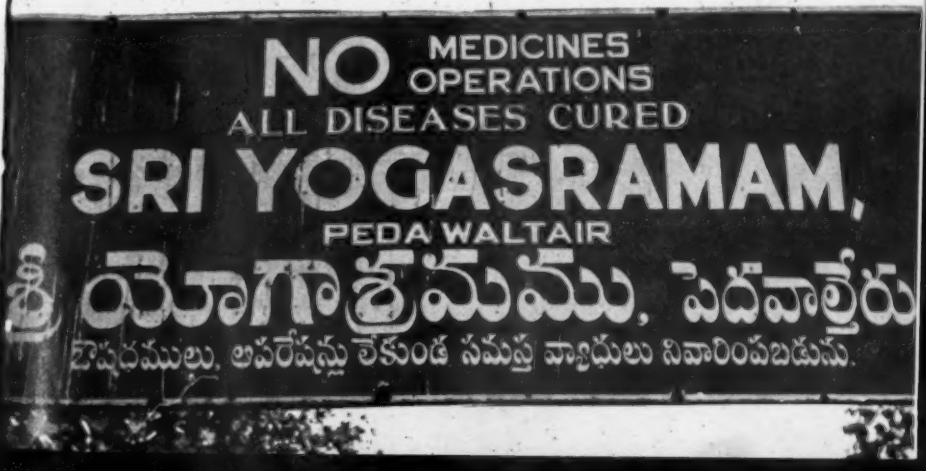
Important seasonal changes

Studies undertaken so far on the physics, chemistry and biology of the Indian coastal waters have yielded some very interesting results. The water mass, particularly on the shelf of the Indian east coast, shows two phases in conformity with the two monsoons, the southwest and the northeast, prevailing over the area during different parts of the year. The features could be summarized as follows:

From January to July the prevailing monsoon is from the southwest. This results in currents running towards the north. The water has a fairly high salinity of 33 to 35 parts per thousand. During this period the plankton grows in considerable concentrations and supports a rich fishery. During the remainder of the year, from August to December, the monsoons are from the northeast, the ocean currents run to the south, and the water is much less salt, about 17 to 25 parts per thousand. The plankton is now scarcer and the fisheries are poor.

Knowledge of the offshore areas both in the Bay of Bengal and the Arabian Sea is wanting. In the Equatorial region of the Indian Ocean, the surface currents show great seasonal variation. This is quite contrary to the more permanent condition of currents in the Pacific and the Atlantic. The south Equatorial current is perhaps the only permanent feature throughout the year. On the other hand, the north Equatorial current is found well developed during the winter months when the northeast monsoon is active. Such seasonal changes in the pattern of surface currents should certainly influence the distri-

OCEANOGRAPHY IN INDIA, *as elsewhere, is a young science. But, as this practitioner's shingle shows, there are other sciences in India of considerable antiquity. The lower script on the sign is in the Telegu language. India has many who cater to the afflicted, including herb dispensers and religious healers, as well as excellent medical men. (E. C. LaFond)*



FLEET'S IN. *Indian fishermen pull their catamarans, with sails furled and masts unstepped, alongside the research vessel in hopes of selling the fish and prawn in the baskets. In such simple craft, local fishermen sail as far as ten miles out to sea, anchor, and fish in the broiling sun with hand lines. The catch must be sold and eaten the same day, due to the lack of refrigeration in the area. (E. C. LaFond)*

bution of the water masses about which we would like to know more. Other interesting problems requiring investigation are the causes for the remarkably flat bottom which is found over very wide areas of the Indian Ocean and the nature of the turbidity currents which occur particularly in the Bay of Bengal and adjacent regions. Also needing study is the nature of the "swatch of no ground," which is a deep water canyon at the head of the Bay of Bengal, and its effect on the hydrography and the submarine geology of the area. Finally, a most interesting problem is that of water circulation in the monsoon ridden parts of the Indian Ocean.

Impoverished east coast waters

Of particular interest to the fisheries biologist in this area is the glaring discrepancy that exists in the gross productivity of sea life between the east and west coasts of India. The waters on the west contribute as much as 85% of the total fisheries landed on the Indian coast per annum. What are the causes that lead to the impoverishment of the waters on the east coast? The biology of the commercially important fisheries in this area is not known and, for the pro-

per utilization of the marine fisheries, knowledge of the breeding habits, areas of reproduction, growth, and other aspects of the local fishes is essential.

All these point out the necessity for a fullscale oceanographic expedition to occupy different parts of the Indian Ocean for an extended period of one year or two. It is only in this way that useful data could be collected.

Tongue of the Ocean

ONE OF THE intriguing puzzles of the sea floor is the Tongue of the Ocean, in the western Bahamas. This embayment, or arm of the sea, is about a mile deep, 130 miles long, and 20 miles wide in the central portion. Yet it is surrounded by shallow water or islands on three sides, so that it has the form of a blind-ended canyon.

So far, no one has been able to explain with complete satisfaction the way in which it came into being. Was it originally carved out by wind and water at a time when the sea was much lower? Was it formed by turbidity currents of muddy water deep beneath the sea surface? Or did it emerge with a violent rift in the rocks of the earth?

A corporate associate of The International Oceanographic Foundation, the Shell Development Company, is interested in the Tongue of the Ocean because geologic formations and oceanographic conditions are similar to those which have produced oil-bearing deposits in the past. It is making possible a preliminary scientific study of the Tongue of the Ocean depths.

Since July, the research vessel *Gerda,* from the Marine Laboratory of the University of Miami, has been conducting research work in the area, which is immediately east of Andros Island. Although of a preliminary nature, these studies provide the basis for future investigations which may determine how and when this underwater deadend was formed.

In turn, such findings should throw new light also on the problems described in the article "Strange Canyons on the Sea Floor," pages 171 to 179 of this number, although the Tongue of the Ocean is quite different from the gorges which Dr. Francis P. Shepard describes.

MOST SUCCESSFUL MODERN YACHT *using centerboard design is* Finisterre, *owned and sailed by Carleton Mitchell. She represents the climax of a long period of evolution in yacht design and architecture. The shoal draft, generous beam, seaworthiness and fine racing characteristics of* Finisterre *give her definite advantages over many deep-draught keeled boats. Astern of her is* Revenoc, *which some consider the parent of today's successful centerboard racers. This striking photograph was taken during the Lipton Cup Races of 1956, off Miami, Florida. (Morris Rosenfeld)*

Is the Centerboard Up?

By EDWIN H. MAIRS
Coconut Grove, Fla.

EDITOR'S NOTE

Recent articles on oceanic research have pointed to the need for new vessels and to the special problems involved in designing them. This is only part of the general question of ship design. Mr. Mairs' previous article on new shrimp boats (Vol. 2, No. 1, March 1956) met with such enthusiastic response from our readers that we invited him to draw upon his extensive knowledge and experience to trace the development of centerboard racing yachts. Here he describes some little known factors that have influenced the architecture of these unique sailing craft, and the historical rôles that both commercial vessels and yachts have played in giving us the modern ocean racer.

PEOPLE interested in oceanography and the sea are always impressed with the local disappearance and reappearance of fishes and ocean fauna. Periodically, in New England waters, the bluefish vanishes from its customary habitat, only to return in great numbers some years later. Some days there does not seem to be a sailfish or a tuna in the sea; two days later many rise to the bait. Even the Loch Ness Monster has a record of erratic sightings.

Lately, many sailors and boatmen have commented on the apparent disappearance and recent reappearance of the centerboard boat. Reputedly an original American species of sailing craft, the centerboarder seems to have reached its peak before the turn of the century and then died out, only to return in recent years. Its reincarnation is the small, shoal draft, ocean racer.

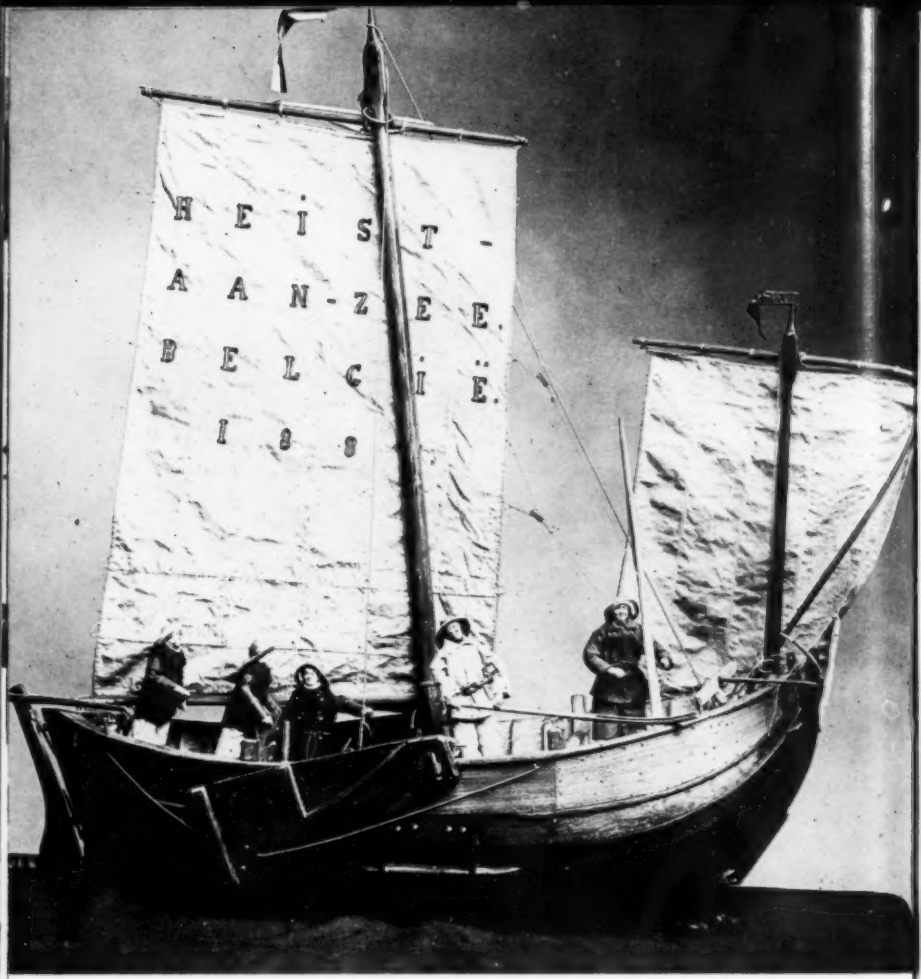
Never Lost Popularity

Actually, the centerboard never lost its popularity with some sailors. For a number of reasons a more dramatic type of racing sailboat caught the eye of the public during the first decades of this century. Only recently has the "forgotten" centerboard been applied to a "new" type boat with sufficient success to attract popular attention. So, let's go back a bit and trace the history of the centerboard, and its apparent death and renaissance.

Although the centerboard, as we know it, was invented in America, the basic idea seems to have been borrowed by the Dutch from the Chinese and South Americans. Leeboards appeared in Holland during the 17th century; later they were used by the French and, to a limited extent, by the British. However, the conception of a centerboard, in a centerline trunk, had to wait another two hundred years.

First "Drop Keel"

Early records show that a British Naval officer, a Captain Schank, while stationed in Boston in 1774, first conceived a centerline "drop keel." However, he was never able to build a centerboard boat on this



QUAINT MODEL *of an early Belgian fishing vessel using a leeboard, here drawn up to show the heavy cleat on the bilge, against which the board rested when the ship was close-hauled. Called "sloops" in Belgium, similar boats are still used for beam trawl fishing. Note the two square-headed lugsails. Leeboards may well be considered the ancestors of the centerboard. (Smithsonian Institution)*

side of the Atlantic. Some years after his return to England, Captain Schank constructed a "drop keel" boat. This was *Trial,* built in 1790, evidently the first vessel to be equipped with a centerboard. *Trial* was 65 feet in length with a 21′6″ beam, and was fitted with three boards. These were not pivoted boards, but were lowered at both ends, a feature that some today regard as a possible modernization of our present pivoted centerboard.

Trial was a very successful boat

and so influenced the British Admiralty that it authorized the construction of over thirty brigs incorporating Schank's design.

Sunk By A Leaky Trunk

About the same time, another Englishman, Samuel Bentham, privately constructed several 80′ schooners and two 113-footers, using "drop keels." Whether his designs were independent or whether he was influenced by Schank's ideas is not known.

Unfortunately, structural problems dogged both of these experiments and it is believed that all of the vessels were converted to conventional types. For several years the centerboarder really did disappear — sunk by a leaky trunk.

The centerboard made its next appearance in the United States. Most shipping was then by water, on the shallow rivers, bays, and sounds of the Atlantic Coast. Conditions demanded shoal draft. The centerboard boat was the obvious answer — an efficient, shallow water, sailing vessel. In 1811 a patent for a centerboard system was issued to the Swan brothers, shipbuilders in New Jersey. This started things rolling and, finally, structural methods were found to make the centerboarder water-tight and practical.

Union Had Two Boards

By 1820 the use of the centerboard had become common in New York and Southern New England waters. It soon made its appearance on the Chesapeake, leading to the "bugeye" and "skipjack."

According to maritime historian Howard I. Chapelle, the earliest plans for a vessel using a centerboard are those of the schooner *Union,* built in the 1820's. It is believed that she was originally an American slaver, 80′ in length, fore and aft rigged, with two pivoted boards, one forward, one aft, of the centersection. During this same period, the United States Government also built a class of 60′ centerboard Revenue Cutters.

Although few pleasure boats were turned out in America previous to 1830, the next decade saw the birth of American yachting. Yachts were even more restricted to shallow coastal waters than were small commercial craft. It was logical to adapt the lines of existing shoal draft, centerboard, cargo, fishing, and revenue cutter types to sailing yachts. History shows that the first American vessel designed purely as a yacht was *Onkahye,* built in 1839.

Gimcrack—Home of N.Y.Y.C.

Onkahye, a schooner, was 96′ overall, 90′ on the waterline, with a 23′ beam. Her design was influenced by that of the New York Pilot boat, although she had a centerboard. Her draft with the board up was 13′. She proved to be very fast and stiff, but hard to handle and uncomfortable at sea. She was sold to the Navy in 1843, and was lost in the Bahamas in 1848.

Although *Onkahye's* owner had drawn plans for her himself, he engaged the services of a young designer, George Steers, to design his next yacht, *Gimcrack.* She was, in effect, a fin keeler and her only claim to fame is that the New York Yacht Club was founded on board in 1843.

LEEBOARDS WERE ATTACHED to each side *of flat-bottomed boats. The board was let down in water on the lee side, so that when the vessel was close-hauled, it would resist the tendency of the boat to drift too far to the leeward when heeled over by the wind. (Yachts and Yachtsmen of America)*

The success of *Onkahye,* a centerboarder, in contrast to the disappointing performance of the fin keel *Gimcrack,* undoubtedly impressed the yachtsmen of that day and helped further the development of the centerboard yacht. George Steers designed several which were very able and helped set the pattern for American yachts for many years.

"Skimming Dish"

At an early stage of the game (in 1851) some members of the New York Yacht Club launched a trend which was to result in later distrust of the centerboarder. This was the development of the dangerous, unstable, lightly-constructed "skimming dish," which reached the height of its popularity in the 80's and 90's.

Simultaneously, yachting was developing rapidly in Great Britain. In British waters, draft was no problem. Stormy winds and rough seas were, and are, the order of the day, in contrast to the average placid state of sea and weather along the shoal eastern coast of the United States. To cope with conditions, the British developed a yacht quite different from that of the Americans. This boat was deep, narrow, and heavily ballasted, later known as the "English Cutter."

With the advent of international racing, after 1850, many American yachtsmen became enamored of this boat and, as American yacht racing was moving offshore to deeper waters, believed it to be a more efficient and faster model than the American centerboarder. The battle between the "cutter" enthusiasts and the "centerboarders" was joined, and discussion at times became bitter. It continues today, but in a less lively manner.

New Racing Rules Needed

As boats participating in racing became more varied—"centerboarders," "skimming dishes," and "cutters"—it became necessary to devise handicapping rules in order to provide equal chances of winning for all types and sizes. Over the years, many rating rules have been used. Almost all of them have affected design, some to advantage, some adversely.

The first American rules were simple, based on tonnage or displacement figures, or a combination of both. They favored a boat low in cubical content and low in actual weight. The American centerboarder

fared very well under these rules. By 1859, waterline length was handicapped and beam was favored, a still more advantageous situation for the centerboard yacht.

Such America's Cup defenders as *Magic* (1870) and *Madelin* (1876) were typical of the comparatively shoal draft, beamy yacht encouraged by these rules. *Magic* was a centerboard schooner, 84′6″ overall, 80′ on the waterline, a little over 20′ beam, with a draft of 7′ without the board. She was very hard at the turn of the bilge. As sail area was not penalized, the spread of canvas was tremendous. These boats were able, fast cruising types, but, due to the rules, they were beginning to be eased out by more radical models, the "rule beaters" of the day.

Capsizing of Mohawk

By 1890 the "skimming dish" had taken over. Typical was the centerboard schooner *Mohawk*, which had an overall length of 110′, a beam of 30′, and a 6′ draft. For better or for worse, she capsized, drowning her owner. This, plus a series of similar tragedies and near tragedies to boats of this type, fostered a distrust of all centerboard yachts. The "cutter cranks" had their chance to run wild.

In order to discourage the design of "skimming dish" centerboarders, both the New York Yacht Club and the Seawanhaka Corinthian Yacht Club took an unprecedented step. They devised handicapping rules which not only aimed at fair racing between boats of different types and sizes but, also, severely penalized undesirable types. The rules struck a balance between waterline length and sail area. Both clubs adopted the new rules in 1890.

Getting Around the Rules

It has been said that nothing devised by man is perfect and this rule was no exception. The intent was to encourage the design of racing-cruising boats. However, because beam and draft were omitted from the calculations, other types than the traditional and proven American model were favored, and the "cutter" became the more popular, as far as large yachts were concerned.

Designers soon found that with no penalty on overall length, a long narrow hull with long overhangs and a short waterline length minimized the tax on sail area and provided a fast racer. Borrowing from the British, they employed heavy outside ballast and combined this with light displacement and light construction.

The fin keel yacht was the result and, finally, the "scow" type came into being. Good size boats were designed along these lines, the largest being the *Independence*, in 1901. Her characteristics show how extreme she was: length overall 140′ 10½″; length of waterline 90′; beam 23′ 11½″; draft 20′. She displaced 146-.75 tons, versus a normal displacement for a modern yacht of this size of almost double that amount—evidence of a shallow molded depth. To top it off she carried over 14,000 square feet of sail. The measurement rule missed the mark so widely that this monstrosity received a more favorable rating than her conservative, cruising type competitors, which the

MODEL *of the* Carrie Price, *a Chesapeake Bay "skipjack" of 1879, showing the centerboard in its lowered position. The skipjack is still a useful workboat, although many of them have been converted into pleasure craft in recent years. (Smithsonian Institution)*

rules were meant to encourage. This was the situation of yacht design in 1900.

Work Boats Hold the Line

While yachtsmen were warring over the virtues of centerboarders and "cutters," the centerboard continued in a commercial role, and found increasing use in work-a-day craft. From the time of the introduction of the centerboard schooner in the 1820's, cargo boats, coastwise schooners, and fishing boats were developed along shoal - draft, center -

boarder lines until their final defeat by power, during the first quarter of the 20th century. The "stone boats," 50-60′ centerboarders, originating in New England for carrying granite, were widely used as short haul cargo carriers. The majority of the schooners on the Atlantic Coast and many of the schooners on the Great Lakes were equipped with centerboards.

These vessels grew larger and larger, culminating in the three and four-masters which, until recently, were commonplace along the Eastern Seaboard. An idea of their size can be gained from the dimensions of the *Governor Ames,* 265′ in length, the largest built. Her centerboard was 35′ in length and dropped 14′.

Spectacular Freaks

Returning to yachting at the turn of the century, we can see many factors which affected future architecture. Until then, yachting was a rich man's sport. Public interest in yacht racing was great, however, and regattas were attended by large spectator fleets. The boats that held common interest were large yachts—defenders of the America's Cup and the like. The best known yachts of the day were spectacular freaks, designed and built as "rule beaters."

General interest in yachting as a spectator sport led to more participation as time went by. Production of undesirable type yachts of the 90's led to the formulation of more stringent measurement rules. Both factors, in their way, paved the road for the "return" of the centerboard to a position of popular trust.

Yachtsmen, themselves, became alarmed by the trend toward unsafe and unseaworthy "rule beaters," as exemplified by *Independence*. As the centerboard had been disgraced by the skimming dishes, and the fin-keel had been discredited by the "scow," interest in the English "cutter" was predominant. In 1901, the Seawanhaka Corinthian Yacht Club devised a new rule, adding the area of the waterline plane and the midsection to the calculations. The New York Yacht Club followed suit.

In 1903 both clubs formulated the Universal Rule, which placed a premium on long ends and beam concentrated amidships. Under this rule the use of a centerboard was almost prohibited by a restriction placing it, in its raised position, entirely under the cabin sole or floor. Some years later, the International Rating Rule was devised in cooperation with English yachting interests. This reflected the British influence even more strongly. It discouraged racing machines, small displacement, large sail area, and excessive ballast. Neither rule was readily adaptable to the design of small racing-cruisers.

"J" Class Is Born

These two rules were used for the next twenty years. In spite of the restrictions contained in them, their use resulted in the design of many strictly racing classes, ending with the last of the America's Cup Defenders, the familiar "J" class.

In the first two decades of the Twentieth Century, yachting began to develop into a widely popular sport. However, racing in restricted classes, as developed under the Uni-

versal and International rules, was not a family venture. These new yachtsmen turned to cruising. Amateur crews became common. This period saw the introduction and growth of the small, strictly cruising boat, combining ease of handling, a simplified rig, and comfortable living quarters. In addition, thousands of day-sailers were built. So great were the numbers of such boats that, one writer estimates, only 9% of the sail boats constructed between 1903 and 1927 were designed with regard to the International or Universal rules.

Who Can Resist A Race?

Although "outsiders" became numerous, they were not the yachts familiar to the public. "Class boat" attracted the general interest of newspaper readers, and rightly so. The 8 Meters, 10 Meters, 12 Meters, the "M" and "J" boats were far more spectacular—the prima donnas. The little cruising boat and day sailer were the invisible supporting choruses. Most of the new yachtsmen were happy to have it that way. They liked their pleasure without fanfare.

However, few are the boat owners who can resist a brush with another boat. Die-hard cruising sailors had no more resistance than their class-racing counterparts. The 1920's saw the start and rapid growth of cruising-class handicap racing. This led to long distance and, finally, ocean rac-

WORK BOATS KEPT THE CENTERBOARD TRADITION ALIVE *when racing yacht owners temporarily turned to "cutters" and fin keels. This early photograph shows Chesapeake Bay "bugeyes" unloading oysters along the waterfront of Baltimore, Md. (Smithsonian Institution)*

ing. With the latter came the development of the modern ocean racer-cruiser.

The first "modern" Bermuda Race was sailed in 1923. Contestants were strictly cruising boats, whose lines and rigs had originated in the previous twenty years. The designers of these craft were not confined by the narrow bounds of the current racing rules, although they were influenced by them. The deep-draft fisherman type schooner, designed for comfortable cruising, dominated the fleet.

"Rule Beaters" Again Move In

The rating rule was very simple, using only overall length, cruising sail area, and a propeller drag allowance. Entries would have led one to believe that the old ideal of promoting races between reliable, safe, cruising boats had been realized. As a matter of fact, only a few years went by before "rule beaters" were designed with but a single offshore race in mind. Again, steps had to be taken to encourage "healthy" types.

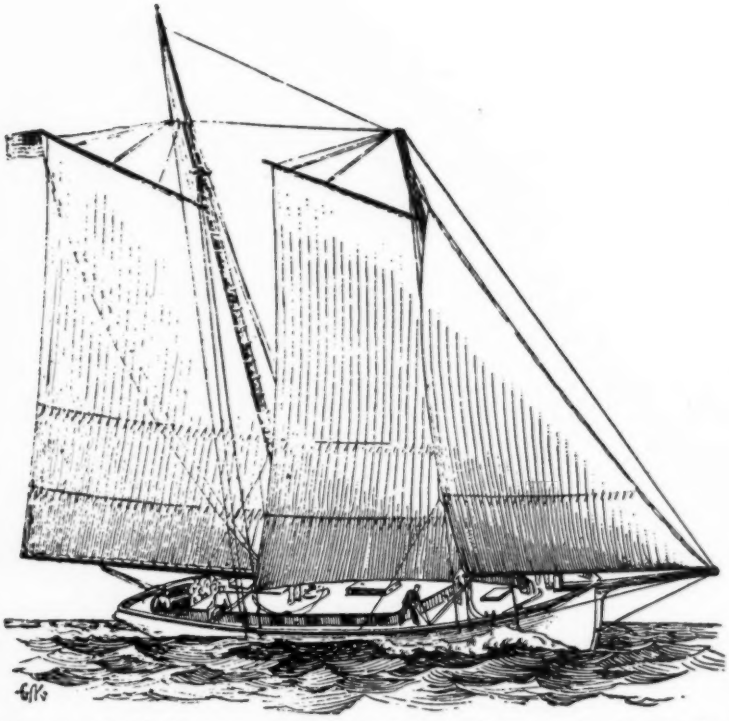
When the Cruising Club of America sponsored another Bermuda Race in 1924, popularity of ocean racing became a certainty. The entrance of this organization into the picture undoubtedly has had more effect on the evolution of the present day sailing yacht than any occurrence in yachting in the last forty years. Due to the Club's farsighted and wise handling of the Bermuda and other races, the aims of a century ago are now being realized.

Between 1923 and 1933 almost every well known ocean and long distance race was firmly established on the East Coast, West Coast, and Great Lakes. In Great Britain, in 1927, the formation of the Ocean Racing Club of Great Britain, renamed the Royal Ocean Racing Club, laid the cornerstone for international competition. Its growth closely parallels that of the Cruising Club of America. Rating rules of these two clubs differ only slightly.

By 1932, several yachts had been built to the joint rule. The most famous of these was Olin Stephen's *Dorade*. A small boat by the standards of the day, *Dorade's* design took full advantage of every Bermuda Rule essential. Many felt that, in doing so, the designer produced a yacht which was more of a racing boat than the cruising boat which the sponsors of long distance and ocean racing wish to promote. She demonstrated that the existing rule encouraged narrow beam, light displacement, and high freeboard, without regard to proportional draft. In effect, it developed a hull with many of the features of a class racing machine.

Return of the Centerboard

The Cruising Club, in 1933, drew up a new rule and held a designer's competition in order to see just how radical a boat would result. The loopholes proved so serious that it was abandoned. Another rule was devised in time for the 1934 season, and it is this rule that forms the basis of the one in use today. Ample beam and shoal draft were encouraged and, for the first time in thirty years, the centerboard was recognized as a possible shipmate on an offshore yacht.



GIMCRACK, *a fin keeler, gave such a disappointing performance that it undoubtedly helped the development of the centerboard yacht in the mid-19th Century. Its only real claim to fame is that the New York Yacht Club was founded on board her in 1843. (Yachts and Yachtsmen of America)*

A great increase in race entries was accompanied by the appearance of several strictly cruising centerboarders, manned by sailors who previously had been die-hard cruising men. The new rule opened the door for the return to racing of the traditional American sailing yacht, which had been banished to the status of the unromantic "cruising tub."

Before 1940, several ocean racing-cruising boats were designed with centerboards. Notable examples are such able craft as *Alondra,* (later *Carribee*) and the powerful *Escapade,* designed by Philip Rhodes. However, such famous yachts as *Stormy Weather* and *Edlu II,* by Sparkman and Stephens, were more typical of the period—being comparatively narrow ships of medium draft.

Scientific Revision Stands Today

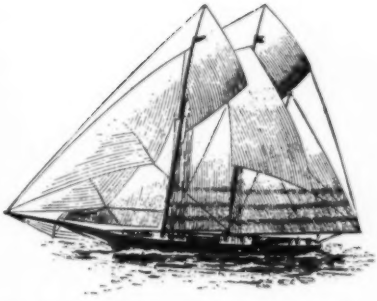
In 1940, the Cruising Club of America presented another new rule, this time a truly scientific revision of the 1934 Rule. It is due to the thoroughness and ability of a rules committee of noted designers, the chairman George E. Roosevelt, and Wells Lippincott, as spark and consultant, that this 1940 rule was formulated. It is in effect today, with only one or two changes, an all encompassing rule that is the most satisfactory ever devised. As did the 1934 Rule, it treated the centerboard kindly. With slight variations, the 1940 Rule is used throughout ocean racing in this country.

World War II brought ocean racing and yacht construction to a halt. After its conclusion, construction costs soared, due to expensive labor, materials and overhead. Financial necessity spelled the doom of the large yacht, both power and sail, and smaller boats became common.

No Longer "Ugly Duckling"

As for the sailing yacht, new owners and old racing men regarded their post-war boat as a source of year 'round pleasure. Sailors became more appreciative of the pleasures of cruising the remote and shoal bays and sounds of the Atlantic and southern Pacific Coast and, in the winter, the warm southern waters. Ocean racing became even more popular than before the War. As few could afford a boat for each purpose, the time was ripe for the arrival of a truly dual-purpose cruising and racing yacht.

Many out and out cruising centerboarders had been designed and built



TYPICAL "SKIMMING DISH" *of the 1890's was the centerboard schooner* Mohawk. *But she capsized and drowned her owner. Similar tragedies and near tragedies to boats of this type fostered a distrust of all centerboard yachts at the turn of the century, temporarily reversing a trend. (Yachts and Yachtsmen of America)*

during the first three decades of the century. To a limited extent, they took part in offshore racing, much to the critical distrust of the old deep keel enthusiasts. Their lines were modifications and modernizations of the old fashioned American centerboard yacht — beamy, short ended and shoal draft. However, they were smaller in size and sported outside ballast on their keels. As we have seen, the Cruising Club of America Measurement Rules were, at last, friendly to this type hull. Although scorned by many offshore sailors, these boats were very efficient, fast and seaworthy due, in part, to recent improvements in rig, hull lines and in the skill of those sailing them. The "ugly ducklings" became "swans" of the ocean racing fleet.

In the July 1946 issue of *Yachting*, under the heading "A Centerboard Yawl for Southern Cruising," appear-

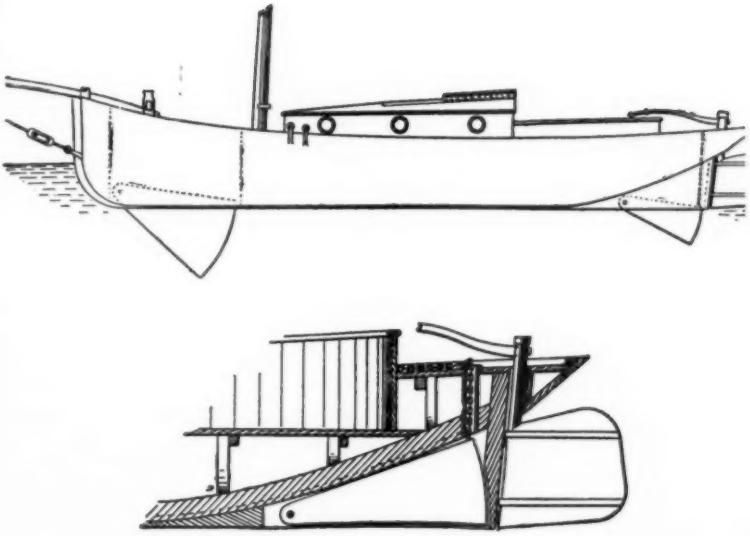
ONE OF THE MOST FAMOUS DEFENDERS OF THE AMERICA'S CUP *was* Vigilante, *a centerboard cutter, which met the challenge of Britain's* Valkyrie *in a spectacular series of races during October 1893.* Vigilante *had previously won out over three other American yachts for the right to defend the "auld mug." (Yachts and Yachtsmen of America)*

ed the plans for a new boat by Sparkman and Stephens. She was described as being 45′ 3½″ overall, 32′ on the waterline, 12′ 1″ beam, and 4′ 4¾″ draft, with the board up. Those familiar with yachting will recognize this as Harvey Conover's *Revonoc*. In comment, the editor added: "—she should have a good turn of speed, especially downwind with the centerboard housed in her lead keel."

This proved to be a prophetic evaluation. Whether her designers and owner were surprised or not, *Revonoc* proved to be very good on all points of sailing. Soon after being put in commission, she started a trophy collection which has been growing ever since. *Revonoc* and her record have done more to revive interest in the traditionally American, centerboard type yacht than any other boat designed in the past fifty years. In addition to racing her successfully, Mr. Conover has cruised *Revonoc* extensively, customarily spending the winter months in the Bahamas.

Mitchell's Finesterre

Some time elapsed before *Revonoc* was fully appreciated. However, in



DOUBLE CENTERBOARDER. *Ingenious placing of the boards in this old design (by Thomas G. Edmondson, of Tarpon Springs, Florida) did not weaken any part of the hull where heavy cargo might be carried. Stern casing also provides a firm point to attach the rudder. (Yachts and Yachtsmen of America)*

the last five or six years she has acquired many daughters — Carleton Mitchell's *Finesterre* among them. Many modern "cutter cranks" are persuaded that the shoal draft, beamy keel-centerboarder has definite possibilities as a fast ocean racer and as a seaworthy, comfortable and practical cruiser, able to go anywhere. Almost every sailing yacht today is built with the Cruising Club of America Measurement Rule in mind, and the vast majority of them are centerboarders. So successful have they been that, only this year, the rules have been altered to decrease their advantage.

Like the vanishing bluefish, the centerboard yacht never did die out, and suddenly reappear. Developed of necessity, it reached one peak of success in the 1880's, suffered abuse, and was legislated out of popular view. After a quiet life in the obscure "cruising tub class" for forty years, it reappeared as a result of the rapid growth of ocean racing. In the last ten years, it has regained the respect of yachtsmen, and no doubt will be improved upon in the future. However, this process of improvement and development, in itself, could well lead again to excesses and monstrosities, and the centerboarder could once more be legislated into obscurity. Let us hope she remains on at least a reasonably even keel!

The Flying Barnacle

By F. G. Walton Smith

The yachtsman or fisherman is accustomed to the nuisance of barnacles, those shelly encrustations which fasten to the hull below waterline and slow down the ship's performance. But he may not know of the belief that persisted for hundreds of years of a barnacle that flew like a bird! As recently as 1884 it was reported from Brittany that the Church continued to exempt geese from its rule forbidding the eating of flesh or fowl on Fridays. Behind the ecclesiastical concession lies the strange myth of a monstrous creature, the goose that grew out of a seashell and was therefore fish rather than fowl.

Eleventh Century Miracle

The goose in question has gone under a number of different names in different places—barnacle goose, bernak, brant goose, clakegoose, and others. Its written history is astonishingly voluminous. In fact, 286 authors are referred to in a scholarly but fascinating book on the subject, written about thirty years ago by Edward Heron-Allen, a Fellow of the Royal Society. Since then little, if anything, has been added and we may safely conclude that the myth is dead. But its history is an absorbing example of a belief which began well before the days of printing, probably before the 11th Century, and which for hundreds of years survived every onslaught of observant and scientifically minded critics.

The bird itself was most often reported from Scotland and Ireland and appears to be what is today known as the Black Goose. Two species of this appear in the British Isles in the winter. One is the Brent, the other is known as the Barnacle, or Barnacle Goose, *Branta leucopsis*. Neither have been known to lay eggs or nest in the places where most often seen and they are now thought to breed in Spitzbergen and Eastern Greenland.

Birds Grow on Trees

The first stories fail to connect the barnacle goose with the shelled barnacle that grows in the sea. Instead, we hear from the Cardinal Bishop of Ostia, Pietro Damiani, that birds are able to grow from trees and that this is known to happen in the island of Ceylon. He explains that the apple-like fruit of the tree bursts open to release living geese, fully fledged.

Somewhere about a century later the story gathers circumstance and the author of the first English encyclopedia, Alexander Neckam, tells us of a bird called bernekle which grows from pine wood when it has been steeped in the seas for a long time.

The first suggestion that the geese were in some way connected with barnacles or at least with varieties of shellfish is given by Giraldus Cambrensis in his account of a visit to Ireland during the reign of Henry II. "There are in this place many birds

THIS ILLUSTRATION, FROM ULYSSES ALDROVANDUS, *1603, shows the supposed origin of the brant or barnacle goos ferom trees. The pendant fruit is almost exactly similar in appearance to a goose barnacle, the crustaceous shell growth found on floating timbers.*

which are called Bernacae. Nature produces them against Nature in the most extraordinary way. They are like marsh geese but somewhat smaller. They are produced from fir timber tossed along the sea, and are at first like gum. Afterwards they hang down by their beaks as they were a seaweed attached to the timber, and are surrounded by shells in order to grow more freely. Having thus, in process of time, been clothed with a strong coat of feathers they either fall into the water or fly freely away...

"I have frequently seen, with my own eyes, more than a thousand of these small bodies of birds, hanging down on the sea shore from one piece of timber, enclosed in their shells, and already formed."

Fish or Fowl?

Giraldus, whose account forms the basis of many of the later stories, also notes the convenience on fast days, of a goose which, because of its marine origin could be classed as fish instead of fowl.

"They do not breed and lay eggs like other birds, nor do they ever hatch any eggs, nor do they seem to build nests in any corner of the earth. Hence, bishops and pious men in some parts of Ireland do not scruple to dine off these birds at the time of fasting, because they are not flesh nor born of flesh."

Stories of the geese that grow on floating logs or develop from barnacles gradually grew more numerous, particularly after the invention of the printing press. But most accounts are simply repetitious of earlier ones, sometimes with due acknowledgment, sometimes without. It is not surprising that the writers who told of sea serpents and other fabulous monsters, Gesner, Olaus Magnus, Hans Egede, and the rest, should give equal credence to the barnacle myth. The later authors, however, dropped the idea of birds growing from trees. The trees became floating logs or ships' timbers and the birds grew from barnacles, shells or worms which in turn grew on the wood.

A Fisherman's Story

Isaac Walton, who maintained that eels are produced from dew or the soil, had no difficulty in accepting the origin of geese from trees or barnacles. In his Compleat Angler, he refers to " . . . barnacles and young goslings bred by the sun's heat and the rotten planks of an old ship, and hatched out of trees . . . "

Jonas Ramus, a Norwegian historian, still gave credence to the myth, 700 years or more after the first written account. In his *Norriges Beskrivelse,* in the year 1735, he writes, "It is said that a particular sort of goose is found in Nordland, which leave their seed on old trees, and stumps and blocks lying by the sea; and that from that seed there grow shells fast to the trees, from which shell, as from an egg, by the heat of the sun young geese are hatched, and afterwards grow up; which gave rise to the fable that geese grow upon trees."

Factual Basis

Most of the writers concerned made no attempt to inspect at first hand either the barnacle geese or the barnacle "shells" attached to floating timber. They were content to repeat the tales of their predecessors and it was not the fashion some centuries ago to examine nature directly. The Greek influence was still strong in science and armchair speculation more attractive than experiment or observation. Some historians and writers of travelers' tales, in fact, drew on pure imagination for their writings. But the flying barnacle turns out to have a factual basis of sorts.

First of all, the barnacle referred to is not the common barnacle or-

THE BRANT OR BARNACLE GOOSE *was once considered more fish than fowl. A strange myth, associating its birth with a seashell, persisted for hundreds of years and resulted in a voluminous and fascinating folklore, as well as a Church edict exempting geese from the rule forbidding the eating of flesh or fowl on Fridays. (Painting by J. Maclair Boraston)*

dinarily found growing on the hull of a ship or on rocks. This, the acorn barnacle, lives in a somewhat conical shell firmly fastened by its base to the wood or rock. Instead, the barnacle of the myth is another type which is known even today as the goose barnacle, and is most often found attached to floating timber by a flexible stalk, in form and proportion not unlike the neck of a goose or swan. Shell and stalk together bear a definite resemblance in shape to a goose. Moreover, the creature is provided with a series of feathery appendages which project from the mouth

of the shell and give the appearance of a folded wing. If the shell is opened the resemblance is increased.

In the "Historicall Description of the Island of Britaine," published in 1586, the author described his search for the famed barnacle. Finally, he found a ship in the River Thames, newly returned from a voyage, from which he was able to remove the barnacles. After opening one he describes it as having " . . . the proportions of a fowl . . . saving that the head was not yet formed, because the fresh water had killed them all (as I take it). Certainly the feathers of the tail hang out of the shell at least two inches, the wings almost perfect, touching form, so that it cannot be denied but that some bird or other must proceed of this substance."

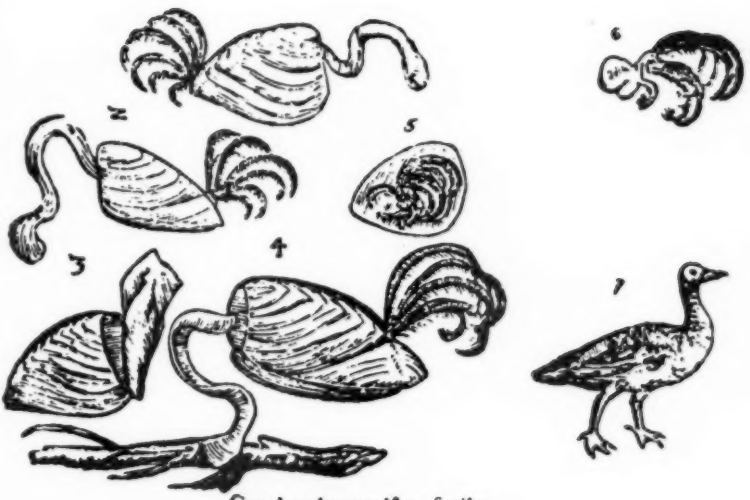
THE GOOSE BARNACLE *as it actually appears. Because of its resemblance to a goose, with long neck and "wing feathers," ancient writers surmised that the barnacle gave birth to geese. They also believed that barnacles grew upon trees, since they were usually found on floating logs.*

3,000 Year Myth

The resemblance between barnacle and bird may have been noticed many years before the first written accounts of the barnacle goose. In fact, there is some evidence that it existed at least two thousand years earlier.

Towards the end of the last century, Dr. Schliemann found a large vase in a huge house in the Agora of the Acropolis at Mycenae. The vase was decorated with a figure that resembled both bird and barnacle. The celebrated British zoologist, Sir Ray Lankester, showed that the wings of the bird corresponded to the appendages of the barnacle and its feet to the barnacle's sexual organ, as the illustration shows. The derivation of geese from trees is also suggested in the decorations of the Ossuary of Crete. Birds, fishes, and leaves are painted together in a way which indicates that the birds originate from the leaves and are associated with the sea.

Whether the Mycenaean vase and Cretean Ossuary are really based on the existence of the flying barnacle myth at that distant time is questionable. They do, however, seem to show that the resemblance between bird and barnacle had been noticed by the artists.



EARLY "COMIC STRIP" *showed by numbers and diagrams the manner in which geese were supposed to originate from barnacles. (From Ulysses Aldrovandus, 1606)*

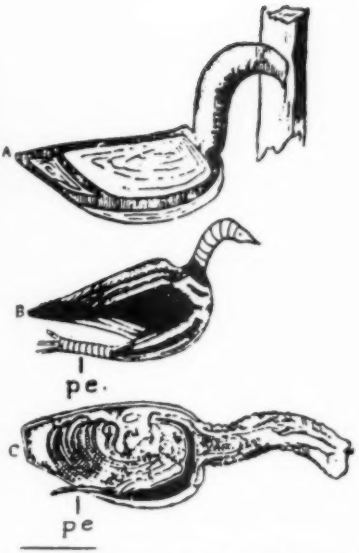
Elusive Miracle

During the several hundred years over which the written accounts of the myth extend there were a few skeptics, writers who were not content to accept mere hearsay, but who examined the myth objectively and in some cases even took the trouble to examine the barnacle itself. As far back as the beginning of the thirteenth century Pope Innocent III forbade the practice of eating the barnacle goose, presumably because he doubted its mythical origin. In 1435 Pope Pius III, visiting King James I of Scotland, attempted to get detailed information on the goose but found it to be most elusive. As fast as he tracked down a place where the bird was reputed to exist, it seemed to disappear. In his own words, the "miracles flee further and further" as they are approached. Albertus Magnus in his "De Animalibus Historia," printed in Rome in 1478, but written in the thirteenth century, ridiculed the myth and stated that he and many of his friends had seen the goose in question lay eggs and hatch them in the ordinary way.

Flying Saucers

The combination of a barnacle that resembled a bird and of a goose that had never been seen to lay eggs in the ordinary way, coupled with the natural eagerness of the uneducated or non-scientifically minded to accept anything with a flavor of the miraculous, sufficiently accounts for the development of the barnacle goose and the goose barnacle. After all, even in the middle of the twentieth century there are those who are gullible

ENIGMA OF A MINOAN VASE. *Near the end of the last century, an archeologist found this decoration on a large vase in the Agora of the Acropolis at Mycenae. Figures resemble both bird and barnacle possibly indicate that the myth originated before the Greeks. (Compare with figures on the following pages.)*



SIR RAY LANKESTER *shows the resemblance between barnacle (top), figure on Mycenae vase (center), and the barnacle dissected open to show the sexual appendage, which compares to the foot of the bird.*

enough to accept stories of visitors from other planets who are supposed to have landed on Earth from flying saucers.

When Fabius Colonna published his "Phytobasanos" in 1592, he included an illustration of the barnacle. He stated clearly that the shells commonly called goose-bearing are not grown from the earth, nor do they give rise to geese but are marine animals and are related to the other common type of barnacle, the acorn barnacle. In 1678, Athanasius Kircher in "The Submarine World" tried to reconcile the facts as he knew them by assuming that the bird lays its eggs on the ice in high latitudes, the eggs break, and the reproductive material drifts south until it becomes attached to ships, where it grows into barnacles and later into geese or ducks. He was not, apparently, aware of the report given by Aldrovandus in 1606, in the third volume of his *Ornithologia,* to the effect that some Hollanders had actually seen the Brant Geese hatching eggs on Nova Zembla and had brought specimens of the bird home.

Unmasked by the Microscope

By 1661 the microscope had been developed and Bartholinus used it to inspect the barnacle carefully. He examined the inside of the shell and concluded that it was made of insects or worms and could not possibly be confused with feathers of birds when magnified by the lens.

At about the same time a book entitled "The Natural Rarities of England, Scotland and Wales" appeared and the author, J. Childrey, says that the "Barnacle or Soland Geese . . . have so infinite a number that they seem to darken the Sun's sight." He is very clear about the origin of these birds. "There hath been great dispute among the learned about the generation of these geese, some holding that they were bred of the leaves of the Barnacle Tree falling into the Waters, others that they were bred of moist, rotten Wood lying in the Waters, but it is since found that they come of an egg and are hatched as any other Geese are."

The Royal Society Taken In

Childrey's remarks not only summarized admirably the nature of the legendary belief but also dismissed

if unmistakably for the falsehood that it was. It is therefore all the more surprising that one year later, in 1661, the first President of the learned Royal Society, Sir Robert Moray, should describe barnacle shells with little birds, perfectly shaped, growing within. "This Bird, in every Shell that I opened, as well the least as the biggest, I found so curiously and compleatly formed, that there appeared nothing wanting as to internal parts for making up a perfect Seafowl." Perhaps he would have changed his mind had he also seen the creatures through the critical eye of a microscope.

Even in the eighteenth century there were occasional remnants of belief in the unique mode of origin of the geese. In 1735, Deslandes rejected the idea of barnacles changing into geese but he provides instead his own imaginative explanation. According to him " . . . certain birds congregate in places where large numbers of shellfish, especially bivalves, are firmly attached to the rocks, or to wood, and there, when laying an egg, they peck at the fish enclosed in these various shells, and put the egg in their place. There is no doubt that these eggs, which are too feeble to hold their position, are fastened into the shells with some viscous and adhesive fluid until the bird bursts the envelope, and taking more nourishment at last can use its wings. That is what in my opinion has led people who inhabit the seashores to say that the shells transform themselves into birds."

From this time onward the story is referred to frequently enough in print but in most cases it is refuted or at least the author expresses considerable doubt. Nevertheless, as we have said earlier, the custom of regarding Barnacle geese as being more fish than fowl, for ecclesiastical purposes continued considerably longer and must be regarded as almost the last survival of this old belief. A permanent reminder, however, exists in a word in the French language which has two meanings, Canard means a duck, but it also means a hoax. And, to this day, the scientific name of the barnacle is *Lepas anatifera,* or the goosebearing barnacle.

Rock Crabs At Chincoteague

LARGE NUMBERS of rock crabs *Cancer irroratus* have recently been caught in upper Chincoteague Bay, along the Atlantic side of Maryland's Eastern Shore. Watermen report the capture of up to three bushels a day, where heretofore only an occasional specimen was caught.

This crab is closely related to the edible crab of the Pacific Coast, and is commercially important in New England. The meat yield is about the same as that of the blue crab of Chesapeake waters.

—Maryland Tidewater News

DARK SHADOWS IN THE SEA *(upper left) trace the course of canyons on the ocean floor just off the doorstep of the University of California's Scripps Institution of Oceanography, La Jolla, California. (Scripps Institution of Oceanography photo)*

Strange Canyons on the Sea Floor

By FRANCIS P. SHEPARD
University of California Scripps Institution of Oceanography
La Jolla, California

ABOUT A CENTURY AGO scientists first observed that there were deep valleys cutting the ocean floor seaward of some of the large rivers of the land. Not much attention was paid to the discovery until, at the turn of the century, an American geologist by the name of A. C. Spencer suggested that the valleys indicated an enormous uplift of the land at the beginning of the ice age. During the period of uplift, the river valley would be cut by water erosion and when the land sank again, this would form the submarine canyon.

Spencer further believed that the uplift was the cause of the great continental glaciers and that the sinking back of the lands to their normal position brought the glacial period to a close.

Source of "Lost Continents" Legends

However, it soon became established by geologists that there had been at least four glacial episodes, with

BLOCK DIAGRAM SHOWS *the relation of San Jose Creek Canyon, California, to the submerged head of Carmel Submarine Canyon in the Pacific. The thin black line represents the surface of the sea. It can be seen that the land canyon in the background slopes down to the shore at the same spot where the submarine canyon begins. (Figure 1)*

relatively warm periods in between the ice invasions. Few geologists were willing to believe that the continents had repeatedly gone up and down many thousands of feet in the relatively short period of time comprised by the ice age. As a result, the idea of continental uplift became generally discredited. Such catastrophic changes of the earth's surface are now generally relegated to science fiction, along with stories of the "lost Atlantis" and the "land of Mu."

Canyons Deep and Numerous

Shortly after World War I, the U.S. Coast Guard and Geodetic Survey began to use echo sounding devices and, with the help of this new rapid system of charting the bottom, the Survey charted large numbers of the canyons on the sea floor. It was found that canyons were far more numerous and much deeper than had previously been supposed. At first, the close resemblance of the newly delineated canyons to river canyons on land led most geologists to conclude that they were cut by rivers during the past when the lands were greatly elevated, and that subsidence had brought them to their present position.

Complications developed, however, when it became known that the can-

yons were essentially a universal feature, being found around all of the major continents except Antarctica, where none have been discovered to date. It proved disturbing to many geologists to believe that all of these major continents had undergone enormous uplifts. Furthermore, the new improved methods of echo-sounding have now begun to show that the canyons continue well outward, to depths comparable to the average depths of the deep ocean. If entirely cut by rivers, this might imply that the oceans had virtually disappeared at some time in the past.

In 1933 Professor Reginald Daly of Harvard University suggested a revolutionary idea, namely, that the canyons were cut by "density currents," or "turbidity currents" as they are now called. These rivers in the sea flow down the slopes of the ocean floor because of a higher density, due to a suspended load of sediment. Such currents had been detected in artificial lakes where studies had been made of river silting. In these lakes the currents are the result of the muddy river water, much heavier than the clearer lake water, and hence capable of moving down the floor of the lake beyond the river mouth.

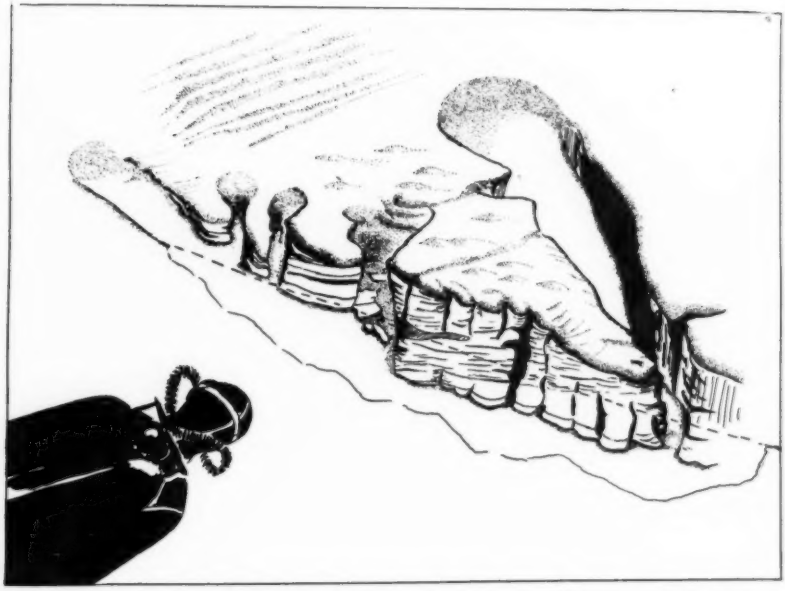
Mud Currents of 60 Miles an Hour?

At first the idea that submarine canyons were due to turbidity currents was not well received. But, with the discovery by Philip Kuenen, of Gröningen University in Holland, that turbidity currents could transport coarse sediments along the sloping floor of a large tank with a turbid type of flow, more credence was given to the theory.

Later, when Maurice Ewing of Columbia University, and various marine geologists at Scripps Institution of Oceanography, found that sand and even gravel deposits are fairly common constituents in cores taken from submarine canyons and on the deep apron-like extensions beyond the outer portions of the canyons, it was realized that some type of strong current must have existed to transport these coarse sediments.

Later, Bruce Heezen and Maurice Ewing called attention to submarine cable breaks accompanying the earthquake in 1929 south of the Grand Banks. These had occurred in sequence down the oceanic slopes beyond the earthquake center. They found that the interval between breaks was such as to indicate to them an enormous speed of current, even up to sixty miles per hour! This report greatly strengthened the hypothesis of turbidity currents as a means of excavating canyons. However, many still unresolved doubts confront this idea as an explanation of the curious canyons of the sea floor.

In order to understand the controversy still in progress between those who believe the canyons were originally cut by rivers and those who think that turbidity currents alone caused the canyons, we must consider the characteristics which the canyons are known to possess. In the first place, not all canyons have the same features. The typical submarine canyon has a roughly V-shaped cross section with steep walls, comparable to the



SKINDIVER'S VIEW OF TWO OF THE TRIBUTARY GORGES *which come into Scripps Submarine Canyon. For scale, note second skindiver on brink of cliff, above junction of two gorges. Wall in foreground has been cut away (dashed line) to show details of opposite side of this branch (Figure 2).*

Yellowstone Canyon, or to the canyons which cut the sides of mountain ranges and the edges of great plateaus. Such a canyon follows a winding course and has many entering tributaries, some of them of major proportions, as for example, the Carmel tributary which enters into Monterey Canyon (Fig. 1). Floors of the canyons, so far as we have been able to ascertain, slope outward quite continuously towards the ocean bottom, which is roughly true also of the land canyons.

Where the Congo Goes to Sea

Many canyons are cut in rock, even in such hard rock as granite. The well explored canyons off California have narrow rock gorges at least in their inner portions near the shore. Aqualung divers have been amazed at the narrowness of the gorges found within a stone's throw of the end of Scripps Pier (Figs. 2 and 3). The same type of underwater scenery has impressed the French aqualungers operating along the Mediterranean Côte d'Azur.

Many of the largest submarine canyons occur adjacent to the mouths of large rivers. The Congo, for example, enters a narrow estuary with depths of 2,000 feet. This estuary represents the landward end of a long precipitous submarine canyon. In view of the enormous amount of sediment

which the Congo pours into the head of the estuary, it seems evident that either this canyon was very recently submerged or that the canyon is being kept open. Since there is no evidence that the coast has undergone recent submergence, it seems certain that the canyon is being flushed of its sediment from time to time.

Similarly it is now well established that the heads of several of the California submarine canyons, including those located directly off the Scripps Institution of Oceanography in La Jolla, are being filled rapidly by sediments. Instead of this material eliminating the canyons by filling them, after a period of from about ten months to a year the canyons undergo a sudden deepening. In two cases these deepenings occurred at a time of a local earthquake, and in one case swirling mud was seen in the canyon head shortly after the earthquake had occurred. At other times, however, the deepening in the canyon heads has taken place without any earth disturbance, and apparently has been due to the instability resulting from piling up of water-saturated sediment on the canyon floor.

Submarine Landslide

It seems likely that landslides occur on the floors of the canyons, turning into turbidity currents at the point where the sliding material is set into suspension. These turbidity currents apparently continue along the entire length of the canyons, because sand layers have been found on the deep floor which fans out at the canyon foot.

Another thing definitely established about submarine canyons is that in a seaward direction they undergo a radical change of character. The inner canyons commonly have steep walls and V-shapes as described above, but traced outward the canyons turn into valleys of very modest proportions.

Furthermore, these outer valleys are often bordered by low rounding ridges, comparable to the natural levees near the mouth of a great river like the Mississippi. Valleys of this kind extend out onto the deep ocean floor beyond the canyons of huge proportions. On land, leveed walls are known to be due to river deposition where rivers flow over the low banks at the margin of their channels. Similarly the turbidity currents may overflow their banks as they fan out across the deltas of the sea floor. Thus they deposit sediment as levees, like those of rivers.

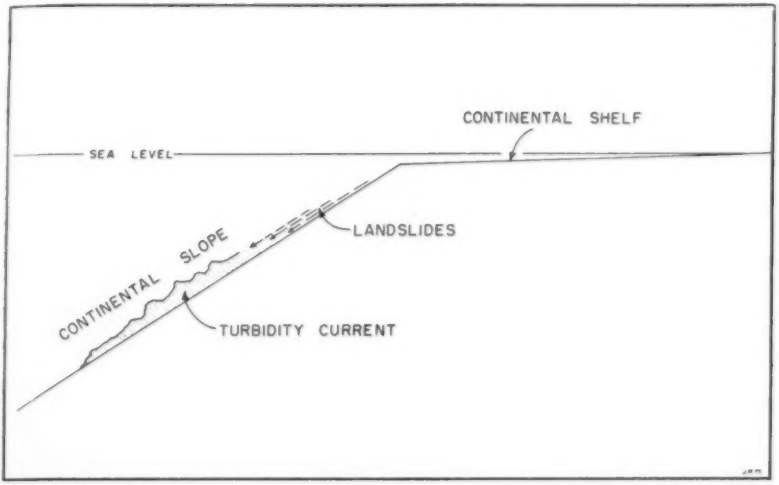
Turbidity Currents Cut Cables

Having established that slides are occurring in submarine canyons and that presumably the slides are turning into turbidity currents, is it not also logical to believe that the canyons themselves were excavated by a combination of these slides and turbidity currents? Possibly this is the case, but unfortunately we still know too little about turbidity currents.

Submarine cable breaks, which Bruce Heezen has been investigating from various parts of the world, are producing an interesting line of evidence. But the estimation of speed, such as the 60 miles per hour computed for the movements of the turbidity currents off the Grand Banks, is still based on very meager evidence.

Two cables broke 120 miles apart at an interval of two hours, but this does not necessarily indicate that a current moved at a speed of sixty miles per hour between the two cables. It is possible that the slide or turbidity current which broke the outer of these two cables was started by the same earthquake that broke the inner cable but well down slope from the inner cable, and thus did not have to move 120 miles in the two hours. It is rather difficult for most scientists to conceive of a current moving down a very gentle slope at express train speed against the terrific resistance of the great mass of the ocean water.

Evidence that turbidity currents are ineffective in erosion comes from cores taken in submarine canyons. Repeated alternations are found between the coarse sediments of the turbidity currents and very fine sediments due to normal sedimentation at the great depths. Presumably turbidity currents, capable of erosion,



HOW UNDERSEAS LANDSLIDES *develop turbidity currents which erode the continental slope. The diagram shows why we find submarine canyons some distance below the edge of the continental shelf. (Figure 4)*

would not have left the fine sediments on the bottom of the canyon. It seems perhaps a little more reasonable that the coarse sediments are transported along canyon floors and out into the ocean basins without greatly eroding the floor over which they are moving.

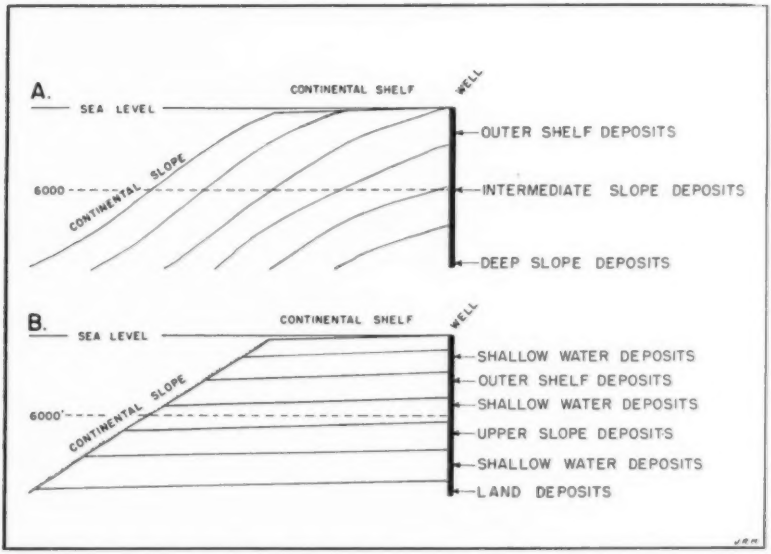
Similarly river floods carry coarse sediment down the river channels without cutting deeply into the underlying floor. In ancient sediments coarse turbidity current deposits have been found overlying surfaces in which delicate leaf impressions were left undisturbed, showing further possibility of transportation of coarse sediment without erosion.

One of the great difficulties with the turbidity current hypothesis as a complete explanation of the canyons is the penetration of these canyons right into the coasts across broad shallow water shelves. If the canyons were cut as a result of landslides setting up turbidity currents, one would expect the chief cutting would occur out beyond the edge of the shelf, where the continental slope is sufficiently steep to generate a landslide (Fig. 4).

ACTUAL UNDERSEAS PHOTOGRAPH *of the side of a submarine canyon in the Pacific, showing the sloping pile of rock debris that has accumulated at the bottom. This remarkable flashlight view was taken at a depth of 300 feet in Scripps Canyon. (Figure 3) (H. B. Stewart and R. F. McAllister photo)*

Were The Continents Lifted?

Thus we should find the heads of our principal submarine canyons on the slopes some little distance below the edge of the continental shelf rather than extending landward across the shelves and into the very margins of the lands. How could one explain the development of such a submarine



EVIDENCE FROM OIL WELLS. *(A) indicates what might be expected from a well, drilled along the coastline, if the continental shelf and slope comprise an embankment of sediment built out over the ocean floor. (B) shows the usual sequence found in wells along the coast, and indicates that the layers under the continental shelf are cut by the continental slope as in the diagram. (Figure 5)*

canyon as that of the Congo on the basis of slides on the outer slopes? Here the canyon actually extends in for fifty miles across the continental shelf and then for another twenty miles into the estuary, within the continental limits.

If, on the other hand, land canyons were cut by rivers at times during the remote past, when the continents were more elevated than now, it would be easier to understand the present day submarine canyons. Persistence of these canyons after they had sunk below the ocean floor is to be expected. The sloping canyon floors would form an ideal place for the development of submarine landslides. The fill carried into the heads of the submerged canyons by rivers, and by longshore currents and waves, would have provided the material which, moving down the canyon floors as turbidity currents and out onto the deep sea floor, could have developed the great fans, with the channels, found beyond the canyons.

Evidence From Oil Wells

If it is granted that the canyons are a joint product of original river cutting and subsequent modification by landslides and turbidity currents, their world-wide occurrence is still a puzzling feature. Fortunately, numerous oil wells penetrate the thick masses of sediments and sedimentary rocks along various continental mar-

gins. If these sediments represent actual building-out of the continental margins into what had formerly been deep water (thus extending the realms of the continents out over the deep ocean basins, as in Figure 5A), then the borings should indicate a successively deeper zone of deposition of the sediments with depth in the boring.

This has not proven to be the case. It seems more likely that the oil wells are penetrating into sediments which alternate between those deposited nearshore in deep and shallow water and on the outer shelf or upper slope (Fig. 5B). They are often interspaced by sediments deposited on the continents themselves. This succession seems better suited to an interpretation of a downwarping of the continental margins, accompanied by an upbuilding of sediments more or less keeping pace with the downwarping. Various wells drilled into the margins of the United States have shown thick columns of this sort; for example, a well at Cape Hatteras, and those of Florida, Louisiana, Texas, and even parts of the California coast. It seems highly likely that similar histories will be discovered around the margins of other continents.

Flat Topped Undersea Mountains

In the ocean basins themselves we find numerous flat-topped sea mountains, commonly called "guyots," which appear to have been beveled by the waves at times when these mountains stood within the realm of wave action. Many of them are now drowned as much as a mile below sea level. Dredgings by Scripps Institute scientists and others have revealed that at least some of these "guyots" have a covering of shallow water sediments which were deposited many millions of years ago. There is, therefore, much evidence to indicate widespread submergence such as might have carried river-cut canyons down deep below the level of the sea.

On the other hand, if sea erosion is capable of breaking great cables, it is possible that some or maybe even most of the submarine canyons have been cut by this action. At the present time, it would be unwise to predicate the final outcome of the controversy between these two major hypotheses for the excavation of submarine canyons.

However, this "progress report," so to speak, indicates the challenging opportunities for research along the perimeters of the great and as yet virtually unexplored realm of the sea.

For Further Reading:

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Radio-Activity And World Fisheries

By DR. D. B. FINN, *Director of Fisheries, F.A.O., United Nations*

THE DISPOSAL of radio - active wastes in the seas and oceans, which is of much concern to world fisheries, poses problems which oceanographers, biologists and other scientists are now trying to solve.

These problems are serious, although at present the danger is potential rather than actual. But it is necessary to have the fullest international collaboration now to acquire knowledge and experience on how and where to get rid of present radio-active wastes, so that, when the time comes, we can be sure of the safe disposal of great quantities.

Widespread Use of Atomic Energy

At present only Canada, Russia, the United Kingdom and the United States of America are actually dis-

posing of a substantial quantity of radio-active wastes, but it will not be long before other nations will be doing so. This is only the beginning. Throughout the world, industrialization is proceeding apace and it is estimated that the energy consumption of human society is doubling every thirty years. Coal and oil, from which so much present energy is generated, are limited resources. There is also a limit to the water power which may be harnessed to produce energy.

There is, however, a large amount of uranium in the earth's crust, and it is possible that many other radio-active elements may be in time used for controlled fission. Nuclear fission as a source of energy is much more efficient per unit weight than coal or oil or water.

We must assume, therefore, that nuclear fission will be a very important source of energy in the future and that the huge increase in energy consumption will continue unabated.

Much Guesswork Thus Far

The radio-active wastes must be disposed somewhere. If they are just dumped in the ocean, there would be an increase in the radio-activity of the seas.

The oceans will be for sometime, however, the most convenient place to dump radio-active wastes. They can absorb the wastes without any great hazard, providing we avoid concentrating radio-activity in any one area, and that the methods and means of disposal are scientifically controlled and technically efficient.

Long-Life Isotopes

At the moment, however, any estimate of the magnitude and speed of increased use of nuclear fission for energy is guesswork. It may grow far faster than we anticipate. It has, in fact, already done so. Not many years ago the estimate was ten or twenty years before industry would have the use of nuclear fission. Yet it is already being used for peaceful purposes and atomic reactor plants are being built for export to various countries. The quicker this development goes on, the more acute becomes the problem of disposal of radio-active wastes.

The United Kingdom and the United States are disposing of radio-active wastes in their adjacent seas, under, of course, the most rigid safety controls. So far as is known, no dangerous concentration of radio-activity has taken place in the disposal areas. But as more and more radio-active wastes accumulate, safe and sure methods of their disposal will have to be devised.

The problem centers on the long-life isotopes. Short-life isotopes can be dealt with quite easily in storage and can be discharged harmlessly into the oceans. But some isotopes in the wastes have a relatively long half-life. For example, strontium 90 has a life of about twenty-eight years and caesium 137 has a life of some thirty-

THE OCEAN REMAINS *the most convenient place to dispose of radio-active wastes, but how much it can absorb without great hazard is one of the important studies being made by scientists during the International Geophysical Year. (U. S. Coast Guard)*

three years. Obviously any method of disposal must more than safely cover the life period of such isotopes.

Mystery of Deep Water Movements

A variety of methods of disposal have been discussed. One is that the wastes should be buried deep in the earth in isolated areas, such as disused mines, but there are various objections to this proposal. Strongly advocated is the disposal of the wastes in the deepest parts of the oceans, but there are a great number of technical difficulties in the way of putting this proposal into effect. Furthermore, although it has been suggested that these very deep bottom waters are rather stagnant, recent investigations tend to show that a good deal of vertical and lateral movement occurs at great depths.

In considering this proposal we are lost in our search for a rational answer because of our ignorance of the ocean depths. We have many theories

BURIAL PLACE FOR *wornout and contaminated radio-active equipment. Giant concentrators, and other pieces of heavy atomic apparatus too "hot" to be repaired, are loaded aboard a railway flatcar and moved into this 500-foot tunnel deep in the mountains near Richland, Washington. Here they may safely be entombed forever, or until such time, many years from now, when they are deemed safe for removal. Land disposal of atomic wastes is much more expensive than that at sea, but danger of subsequent contamination is admittedly less. (General Electric photo)*

but little fact regarding the age and direction and speed of movements of such waters. Some oceanographers believe that the exchange in great depths is so slight that they remain stagnant for several hundreds of years, while others point out that this cannot be the case.

What of Underwater Earthquakes?

Apart from any gradual change which may take place in the deep waters, there is also the possibility of a cataclysmic change, such as may occur in underwater earthquakes. Again, it has been proposed that radio-active wastes should be dumped in deep trenches and canyons which we know exist in some of the oceans. But these canyons are subject to mud slides every few years which keep them scoured.

Even if dangerous radio - active wastes were encased in concrete or other material, there could be no guarantee that the activity in the canyons would not smash the containers.

Fish Concentrate Radio-Activity

The sea has, of course, natural radio-active properties. It contains such elements as potassium 40, ionium, radium, uranium and other radio - active substances. The natural radio - activity of the oceans is only about a tenth of the natural radio-activity on land, which comes from the cosmic rays of the sun as well as the elements in rocks. Fish and other living organisms in the sea concentrate radio - active elements in their bodies. The concentration in living tissue may range from 1,000 to 100,000 times more than in an equal amount of surrounding sea water.

This propensity of fish and living organisms to concentrate radio-active elements is one of the dangers inherent in the disposal of radio-active wastes at sea. If the radio-activity of the water were heavily increased in a restricted area, it could result in the death of marine life, or it might be sufficient to cause a dangerous concentration of radio-active elements in fish and in other marine fauna and flora which are eaten by man.

Mobility of Sea Creatures

When we look into the problems associated with the disposal of radio-active wastes, the picture becomes more and more complex. Phytoplankton and other marine plants and seaweeds accumulate radio-activity rapidly. Fish and other animals which feed on such plant life would take up the radio-active elements with food, even though the water they were swimming in was not radio - active itself.

Then, again, there is the danger that fish swimming through an area where radio-activity is high may become contaminated and then, per-

BECAUSE MUCH OF *the world's food comes from the sea, beyond territorial waters, the problems posed by the disposal of radio-active wastes into the oceans are more international than national. One of the organizations already studying the question is the United Nations Scientific Committee on the Effects of Atomic Radiation. (Robert Ellis)*

haps, may themselves be eaten by bigger fish hundreds of miles away from the contaminated waters. The fish which had eaten them would become radio-active.

What About the Deep-Sea Eel?

Take the case of the deep-sea eel which lives at great depths and may become contaminated. This, perhaps, would not matter so much if the eel stayed at great depths, but it comes up to spawn on the surface. If it were charged with radio-active elements, perhaps the eggs would be radio-active. Many of the eggs and larvae of these deep-sea eels are eaten by other fish.

There is also the case of ordinary eels and such fish as salmon. These creatures move from the rivers and streams to the sea so that if they became contaminated they would carry radio-activity from the sea to the streams, or from the streams to the sea. The Pacific herring is another example. This fish spawns in the coastal areas and in the estuaries where it might become contaminated and carry contamination on its migrations. Other roaming fish, such as tuna and swordfish, could easily carry radio-activity over thousands of miles of ocean.

It will be remembered that following the atomic explosion at the Bikini atoll it was found that the sea had temporarily become more radio-active as far as 2,000 kilometers west - north - west and 1,000 kilometers west - south - west, from the atoll, but after a time the waters were so mixed, this increased activity could no longer be detected.

Danger to Continental Shelf Waters

This enormous spread of radio-activity provides an example of what might happen if heavy concentrations of radio-active wastes disposed in limited areas of the ocean got free to spread.

These are some of the difficulties connected with disposal of radio-active wastes. In particular, there arises for fisheries the possible contamination of the waters of the continental shelf and of the shallow marginal seas. These are the most dangerous areas in which radio-active wastes could be dumped, because of the concentration of fisheries in them and their closeness to the shore.

It must be assumed that greater quantities of radio-active wastes will be dumped in coastal waters. The questions to be answered are how, where, and how much radio-active wastes are to be disposed in these waters without danger. These are questions to which oceanographers must find the right answers in the near future.

As noted above, the most rigid and exacting safety controls are exercised over the discharge of radio-active wastes into the sea. Exhaustive investigations have been made to ensure that neither the fishing resources nor man himself are harmed. In this connection, the health physicist of the United Kingdom Atomic Energy Research Authority, testifying at a public inquiry on plans for establishing an atomic energy station, said that he personally was far more afraid of the discharge of crude sewage into coastal waters than he was of radio-activity!

Essentially an International Problem

The problems posed by the disposal of radio-active wastes into the oceans must be viewed objectively and unemotionally. Mankind has always been exposed to a certain amount of radiation and radio-activity, without adverse effect.

Governments already operating atomic energy programs have put their outstanding scientists to work

ATOMIC BUG MAN. *This is not a man from Mars, but a practical means of detecting and quickly reporting radiation intensity in a "hot" zone of the Hanford plutonium plant, Richland, Wash. Using a throat microphone and head antennas, an inspector can flash word to a central control point if certain areas, which workers must enter for brief periods, have reached the danger point. Thus can radiation easily be spotted on land; in the sea, detection is more difficult. (General Electric)*

investigating fundamental biological and physical principles in relation to atomic energy. The whole question of the biological effects of atomic energy has been referred to the United Nations Scientific Committee on the Effects of Atomic Radiation.

It is surely no exaggeration to say that this question of the disposal of radio-active wastes is one of the most vital facing oceanographers, biologists and other scientists of the world today. We must do an enormous amount of research and investigation to ensure that we find the right answer to the problem, so that as the volume of radio-active waste material grows, we shall be able to dispose of it safely. This is not a national but an international problem. It is essential that it should be tackled on an international basis.

A great deal of work has already been done. There was evidence of this at the International Conference on the Peaceful Uses of Atomic Energy, held in Geneva in August 1955, and, more recently, at the meeting on oceanographic information with possible bearing on the sea and ocean disposal of radio-active wastes, held at Gothenburg in January this year. This meeting was attended by twenty-four scientists from nine different countries and organizations. The present state of progress was reviewed and the path for future research and investigation was defined.

FAO, of course, participated in both meetings. The Organization will continue to do all it can to focus attention on this problem. It also recently established a section, headed by Dr. R. A. Silow, an atomic energy specialist, to deal with the applications of atomic energy in agriculture.

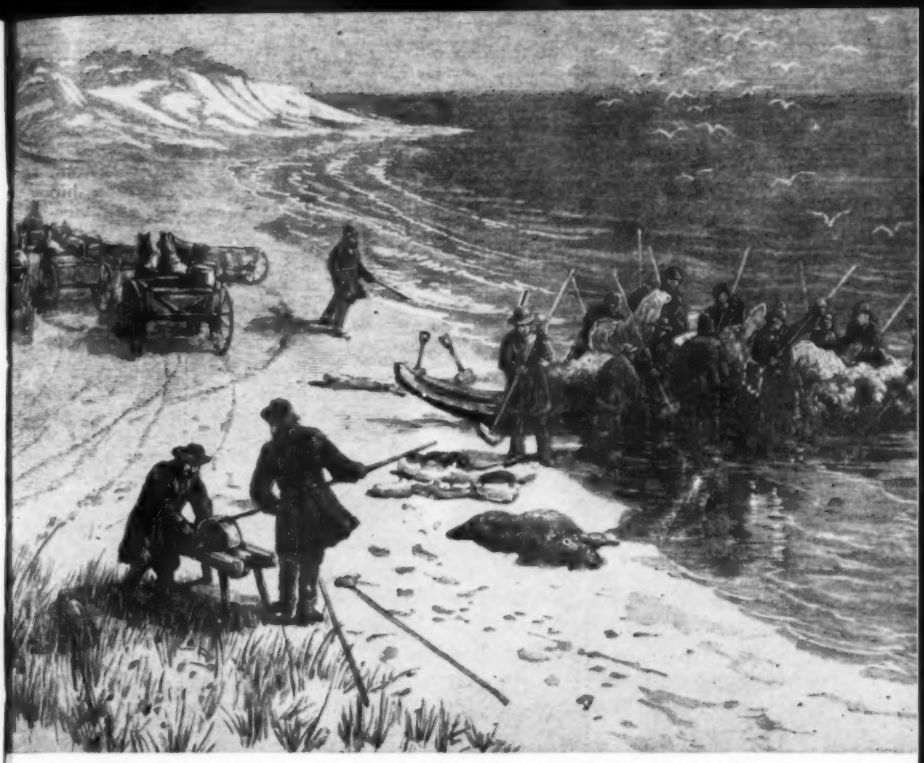
Anglers and Fishermen

THE TENTH Annual Meeting of the Gulf and Caribbean Fisheries Institute will be held at the Empress Hotel, Miami Beach, from November 11 to 15, 1957. Since the International Game Fish Conference held in Nassau, Bahamas, last year was such an outstanding success, a second conference will be held in conjunction with the Institute's meeting, on November 16 and 17.

The fisheries meeting will cover a wide range of problems connected with the food fisheries, and is open to all persons interested. Of particular importance will be sessions devoted to a review of the past ten years progress in research and development.

The Game Fish Conference should interest salt water anglers, since they will have an opportunity to meet their fellow anglers from overseas, along with scientists of international repute who are devoting themselves to a study of the saltwater fishes. Anglers wishing to attend should write to the Secretary, Game Fish Conference, at the address given below.

Those wishing to attend the commercial fishing sessions should write to Dr. C. P. Idyll, No. 1 Rickenbacker Causeway, Miami 49, Florida.



WHALING OFF LONG ISLAND. *A drawing from* Harper's Weekly, *about 1878, shows the "cutting in on the whale" along the beach near East Hampton. Wagons then hauled the blubber to the local tryworks, where it was rendered into oil.*

Science of the Sea in Books

WHALE OFF!

EVERETT J. EDWARDS AND JEANNETTE EDWARDS RATTRAY. Coward-McCann, Inc., New York, 1957. $10.00.

When most of us think of whaling, it is in terms of Arctic or Antarctic waters, or perhaps the far off South Pacific. So it comes as something of a surprise to learn, through a chatty and highly informative narrative, that quite a lot of daring whale hunting took place right off the beaches of eastern Long Island.

All this happened some years ago, between 1640 and 1918, to be exact, but the whaleboat seamanship, the harpooning skill, and the recovery of the big wily mammals required no less courage and know-how than were demanded of those who sought their dangerous quarry in more distant waters.

On Long Island, however, whaling was an exciting interlude for a few hardy men, who spent most of their time farming and netting small fishes. "Shore whaling," they called it, with beaches and coves substituting for mother ships where the big creatures, subdued, were cut up and rendered ("tried out" is the whaling term) into the valuable whale oil of commerce. "Whale Off!" is in two parts. The first, largely reminiscences of the veteran Captain Joshua B. Edwards, as related to his son Everett, describes

the thrills of the whale chase and the everyday work and play of shore whalemen. The second part, by the granddaughter of "Cap'n Josh," traces the course of an industry that brought a modest prosperity to easternmost New York State in Colonial times and did not begin to decline until the discovery of petroleum in Pennsylvania.

There is an introduction by Dr. Roy Chapman Andrews, who saw his first whale in the flesh at Amagansett, and obtained its skeleton and baleen for the American Museum of Natural History. Of interest to oceanographers is a list of "Nautical and Local Terms used in Shore Whaling," and unpublished photographs of whaling operations, equipment, and the men who followed this hazardous calling. "Whale Off!" fills a gap in our knowledge of round-the-world whaling.

E.J.L.

EARTH, SKY AND SEA.

AUGUSTE PICCARD. Oxford University Press. New York. 1956. $4.

Professor Piccard's book on the Bathyscaphe is written for the layman, but it contains sufficient technical data to interest the marine scientist. In describing the development of the device which has taken man to the sea bottom nearly three miles deep, Professor Piccard has avoided any of the dramatic overemphasis which this type of subject is apt to encourage.

Instead he has given a clear and factual account of the way in which the principles of his stratosphere balloon have been reversed for travel to the depths of the sea.

The question of the value of the deep diving machines to oceanography is dealt with briefly but realistically. No extravagant claims are made. The author fully recognizes that, just as the sounding balloon, with measuring instruments and radio transmitter, has replaced the manned balloon, so do automatic measuring and sampling devices play most important parts in deep sea research.

This book will give both the layman and scientist a close acquaintanceship with the practical aspects of underseas research and exploration. Not the least impression left with the reader is that a trip to the ocean floor can now be made without undue risks.

F.G.W.S.

METEOROLOGY FOR MARINERS.

Meteorological Office of the British Air Ministry. Her Majesty's Stationery Office 1956. pp. 274. 103 ills. 1 Pound Net ($2.80).

Sailing ship days, when wind and weather could mean a considerable improvement or perhaps a deterioration of the normal comforts of life at sea, have been replaced by more or less weather-independent time. Now the skill of officers largely is concentrated on the proper use of the ship's instrumentation, and not so much on their judgment, based on experience, in taking advantage of every weather condition.

On the other hand, understanding of the different processes governing changes in the weather and the general rules for weather development has grown in importance since the early days of sailing. Weather and sea are still powerful, and knowledge of practical meteorology and oceanography is extremely useful to all deck officers on modern ships. The efforts of the staff of the Meteorological Office of the British Air Ministry, therefore, will be appreciated by all mariners.

This useful book, in seven parts, deals with the most important elements of meteorology, climatology, weather forecasting, ocean currents, ice and oceanography. Chapters having outstanding importance for mariners, such as currents, tropical storms, ice and visibility, are particularly well done. The practical use of our knowledge in order to take proper care of the ship, and the intelligent employment of the aids to navigation, such as radar, weather bulletins and forecasts, all get due attention.

The short outline of oceanography, which closes the book, covers most sections of general oceanography, and

gives the reader concise information of the world beneath the sea's surface, as well as the transition zone between the sea and the atmosphere, with their relationships to geology, biology, physics and chemistry. In its condensed form, the book is easy to read, and perhaps the only criticism of it that might be made is the lack of a reference list of books for further reading.

"Meteorology for Mariners," which may well serve as a text book for Masters and Mates, will be of great use also on all ships. Through reading it, many owners of small craft should be encouraged to take further interest in the theoretical aspects of weather, and its corelationship with the sea. F.F.K.

Sharks In Indiana?

SHARKS once roamed the seas of Indiana. But this was some 240 million years ago, according to scientists from the Chicago Natural History Museum, who recently discovered the fossil remains of a nearly complete shark eight and a half feet long. If complete, probably it would have been fifteen feet long.

The find is considered noteworthy because of the shark's well-preserved skin (shagreen). Fossilized skin of a creature that lived as long ago as this shark is an extremely rare discovery. The skeleton probably was buried in mud almost immediately after its death, hence the well-preserved condition of the skin, vertebral column, fins and skull of the specimen.

Fishes, Islands and Currents

SURFACE living fishes of the open ocean, such as the tunas, have often been observed to congregate near islands and banks. At first sight this may appear to be quite unremarkable and hardly worthy of scientific attention.

But on further examination it is not too obvious why these pelagic, or open ocean fishes, should be attracted. If the islands provide sources of food, how does this come about? Does the island obstruct or cause a deviation in the regular drift of water past its shores? This might cause upwellings of deeper water, which is richer in the fertilizer salts that support plankton and so, indirectly, fishes.

An attempt has recently been made to study this problem by the research vessel *Spencer F. Baird* at Alijos Rocks and Clarion Island, off the west coast of central Mexico. The Inter-American Tropical Tuna Commission and Scripps Institute of Oceanography jointly conducted chemical, physical and biological observations in the neighborhood of these islands. Their reports will be awaited with interest.

About The Authors

DONOVAN BARTLEY FINN

Dr. Finn, who has been director of the Fisheries Division, Food and Agriculture Organization of the United Nations since 1946, was born in London and educated at the University of Manitoba and Cambridge. Much of his professional experience was obtained in Canada, where he was successively Director of The Fisheries Experimental Stations at Prince Rupert, B. C., and at Halifax, N. S., Chairman of the Salt Fish Board of Canada, and Deputy Minister of Fisheries for the Dominion. During World War II. Dr. Finn represented Canada as delegate and advisor to various international fisheries and food conferences. He is a member of the Rideau University Club of Ottawa, and the Cosmos Club of Washington, D. C. He directs the Fisheries Division, FAO, from Rome.

FRANCIS P. SHEPARD

Dr. Shepard's interest in submarine canyons started in 1923, with early work off the New England coast, then extended to the sea floor off California in 1933, with later investigations of canyons in many parts of the world. In 1955 he spent several months with the French submarine geologists exploring the canyons of the Mediterranean.

A native of Brookline, Massachusetts, he took his B. A. at Harvard in 1920, and his Ph. D. at Chicago in 1922. Teaching at Illinois and service with the Division of War Research, University of California, preceded his joining the staff of the Scripps Institution of Oceanography in 1945. In 1948 he became Professor of Submarine Geology.

In addition to teaching graduate classes, he has been carrying on research in submarine topography, marine sedimentation, and shore and beach processes. Since 1951 he has been Director of the American Petroleum Institute Project 51, which is concerned with study of the nearshore recent sediments, and their environments.

T. S. SATYANARAYANA RAO

Dr. Rao has been on the staff of the Department of Zoology, Andhra University, Waltair, India, for the past eight years. He was born on the 10th of October, 1926 in the village of Motagondanahalli, near Bangalore City, South India. He obtained his Bachelor's degree at the Central College, Bangalore. Later on he joined the Andhra University where he did teaching zoology to graduate students.

In his spare time he has studied the crustacean parasites of some of the food fishes of the Waltair coast. For this work he was awarded a Master's degree. From 1953-55, he worked as a fellow of the National Institute of Sciences of India and it was during this period that he took part in most of the oceanographic cruises conducted by the Andhra University. He worked on the data collected by these cruises and prepared a thesis entitled "Studies on the Chaetognatha in relation to the Biology and Hydrography off the Indian Coast" for which he was awarded the D.Sc. degree of the Andhra University.

Dr. Rao is now in the United States as a visiting scientist under UNESCO fellowship and is at present working with Dr. Ketchum at the Woods Hole Oceanographic Institution, Woods Hole, Mass. He has been here to get fully acquainted with recent trends in oceanographic research. His chief research interests are suspended matter and transparency in the sea and planktonology. At the Andhra University, his special fields of teaching are hydrography, marine ecology and zoogeography.

SCIENTISTS AND AUTHORS

In order that the Bulletin may fully reflect the international nature of its membership and of its objectives, the editor will be glad to consider for publication illustrated articles for the general reader dealing with institutions of marine science or with recent scientific discoveries related to the oceans.

Progress

IN THE SHORT PERIOD of its life, the Bulletin has now reached a circulation of 12,000, not all of whom are members. They are drawn from the United States, Canada, Central and South America, Great Britian, Australia, France, Germany, Italy, Denmark, Sweden and Norway, as well as a few from the Pacific Islands and the West Indies. Continued improvement will be possible with growth of active membership. It will be seen in better service, with more articles in the Bulletin of high interest and authenticity and, eventually, a monthly issue in full color.

Members are joined in these aims and they are urged to make progress possible by taking the small effort needed to enlist new members. To those who are not members, but whose interest and curiosity lie in the sea and the spirit of discovery, there is extended an invitation to participate by simply mailing a card. The ocean is our last frontier and its exploration still under way.

The editor will be glad to consider for publication articles and illustrations covering explorations, discoveries or advances in our knowledge of the marine sciences or describing the activities of oceanographic laboratories or expeditions in any part of the world.

The International Oceanographic Foundation

"To encourage the extension of human knowledge by scientific study and exploration of the oceans in all their aspects, including the study of game fishes, food fishes, ocean currents, the geology, chemistry, and physics of the sea and the sea floor."

MEMBERSHIP

The Foundation was established by a group of saltwater anglers, yachtsmen, shipowners, marine scientists and others interested in the scientific exploration of our last frontier, the ocean. Its objectives are to provide support and encouragement for marine research, exploration and discovery and to promote the collection and dissemination of scientific knowledge about the ocean.

Qualifications for membership are an interest in the oceans and a desire to extend and develop scientific research and exploration into them. Support given to research through personal activities or donations is recognized by the Foundation through the following classes of membership. Members are those who make annual contributions of $5, Fellows $25 annually; Life Fellows are those who contribute $200 or more or who have otherwise helped to advance the purposes of the Foundation; Sponsors who contribute $1,000 or more; and Patrons who contribute $5,000 or more.

Four dollars of each annual donation covers the cost of subscriptions to *Sea Frontiers* and *Sea Secrets*, the official publications of the Foundation.

According to a ruling of the U.S. Treasury Department, donations made to the Foundation are deductible in computing taxable income as provided for by the 1954 code.

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